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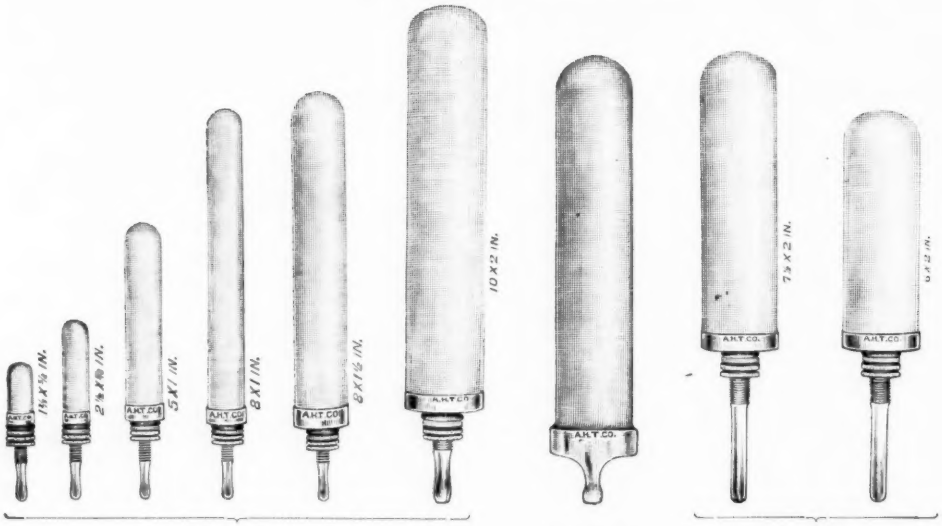

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PHYTOPATHOLOGY

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THE LIFE HISTORY AND PARASITISM OF EOCRONARTIUM MUSCICOLA

HARRY M. FITZPATRICK

WITH ONE PLATE AND FOUR FIGURES IN THE TEXT

The genus Eocronartium was established by Atkinson[1] on a small hymenomycetous fungus occurring in North America on living moss. Earlier investigators had believed the fungus to be a species of Typhula, probably identical with *Typhula muscicola* Fries, and specimens were deposited in many herbaria and distributed in several exsiccati under this name. A critical microscopic examination demonstrated, however, that the basidia are transversely septate, and Atkinson recognized in the species a member of the Auriculariaceae. Since it does not fall readily into any of the previously described genera of the family he erected for it the new genus, naming the species *Eocronartium typhuloides*.

Several years later von Höhnel[2] examined microscopically the sporophore of the moss-inhabiting European species *Clavaria muscigena* Karsten, and found that its basidia also are transversely septate. His studies led him to believe, moreover, that this species is identical with *Eocronartium typhuloides* Atkinson, and probably also with *Typhula muscicola* Fries. The writer in the present investigation has attempted to verify these assumptions.

Both Atkinson and von Höhnel state that *Eocronartium typhuloides* is parasitic, and von Höhnel points out as evidence of this the fact that the fruit-bodies always arise from the buds of the moss plant and are enclosed at the base by its leaves. Neither investigator, however, discusses the effect of the fungus on the host, refers to the degree or type of its parasitism, or demonstrates the presence of endophytic mycelium. In so far

[1] Atkinson, G. F. Preliminary note on two new genera of Basidiomycetes. Jour. Mycol. **8**: 106–107. 1902.

[2] Höhnel, Franz v. Fragmente zur Mykologie IX, Nr. 407–467. Sitzber. K. Akad. Wiss. Wien. **118**: 1461–1552. 1909.

as the writer has been able to determine, no subsequent account of an investigation of the fungus has appeared, and no photograph illustrating the habit or form of the fruit-body has been published. A further investigation of the parasitism of the species is, therefore, desirable.

Several factors combine to make this species of more than ordinary interest. Since there are relatively few fungous parasites of mosses and these imperfectly understood, considerable importance is attached to the investigation of the intimate relation which exists between this parasite and its host. The presence of parasitic species in the Auriculariaceae is, moreover, of peculiar interest since it is possible that careful study of the life histories of these forms will shed light on the origin of the high degree of obligate parasitism present in the closely related group the Uredinales. A critical investigation of the morphology of these parasitic species of the Auriculariaceae may also contribute to a solution of the vexing problem of the origin of the rust fungi.

MATERIALS AND METHODS

The present investigation of the parasitism of Eocronartium is based chiefly on collections of material made during the past four years at various points near Ithaca, N. Y. The fungus, though not common, has frequently been collected in this locality, and abundant material for study has been obtained. The development of the fruit-body has been watched carefully in the field throughout several growing seasons, and frequent collections for microscopic examination have been made. A total of many hundreds of diseased plants bearing sporophores have been available for study during the progress of the investigation. Sporophores of the fungus, and both healthy and diseased host plants have been imbedded in paraffin and studied in serial section. The material was fixed in medium strength chromo-acetic acid fixing solution, and Haidenhain's iron alum-haematoxylin and Flemming's triple stains were used.

Although Eocronartium occurs on a considerable number of species of mosses in various genera the writer's investigation of its parasitism has been limited to three hosts, *Climacium americanum*, *Amblystegium serpens* and *Brachythecium oxycladon*. This has been necessitated by the lack of abundant material of the fungus on other hosts. By far the largest amount of material has been obtained from *Climacium americanum*, and this moss has as a result served for the major portion of this investigation (fig. 5).

The examination of all the specimens of Eocronartium available to the writer shows that this fungus has been collected on the following species

of mosses.[3] These are all members of the two closely related families, Leskeaceae and Hypnaceae.[4]

LESKEACEAE

Anomodon rostratus (Hedw.) Schimp.
Anomodon sp.
Leskea obscura Hedw.
Leskea polyantha Hedw.
Thuidium delicatulum (L.) Mitt.
Thuidium minutulum (Hedw.) Br. et Sch.
Thuidium sp.

HYPNACEAE

Amblystegium serpens (L.) Br. et Sch.
Amblystegium varium (Hedw.) Lindb.
Amblystegium riparium B. et S.
Amblystegium sp.
Brachythecium oxycladon (Brid.) Jaeg. et Sauerb.
Brachythecium sp.
Climacium americanum Brid.
Climacium dendroides (L.) Wb. et Mohr.
Climacium Kindbergii (B. et C.) Grout.
Entodon seductrix (Hedw.) C. Müll.
Hypnum chrysophyllum (Brid.) Bryhn.
Plagiothecium Muellerianum Schimp.
Pylaisia intricata (Hedw.) R. & C.

ENDOPHYTIC MYCELIUM

In the absence of conclusive proof of the parasitism of Eocronartium, it has seemed possible that the sporophores though described as occurring on living moss, arise in reality from saprophytic mycelium. The results of the present investigation leave no doubt, however, of the actual parasitism of the species.

[3] *Acknowledgments.* The species of host plants mentioned here and elsewhere in this paper have been in all cases identified by Doctor A. L. Andrews, the prominent American student of the mosses and author of the Sphagnales in North American Flora. Many specimens of Eocronartium were placed at the disposal of the writer at the New York Botanical Garden through the courtesy of Doctor W. A. Murrill. The portion of the investigation concerned with spore germination was carried on with the aid of Doctor E. W. Olive at the Brooklyn Botanic Garden. The writer wishes to acknowledge here his indebtedness to these gentlemen, and express his appreciation of their services.

[4] Grout, A. J. Mosses with hand lens and microscope. 1903–1910.

Field observations in the early summer reveal the young sporophores just beginning to form at the apices of the branches of the host. Even a superficial examination is sufficient to demonstrate that these are formed from mycelium arising in the interior of the plant and growing out among the leaves at the growing points. That the host is alive and in the growing condition is evidenced by the further development which it undergoes in the early summer while the sporophores of the fungus are advancing toward maturity.

A microscopic examination of stained sections of diseased plants not only gives conclusive corroborative evidence of the parasitism of the fungus but also discloses the fact that the relation between host and parasite is an unusual and extremely interesting one.

In *Climacium americanum* and in the other hosts of *Eocronartium muscicola* which have been sectioned, all the cells of the gametophore[5] fit tightly together, intercellular spaces being wholly absent. Each branch of the gametophore is provided at its tip with an apical cell which by division forms other cells. The resulting tissue is clearly embryonic, being composed of small thin-walled, more or less isodiametric cells rich in protoplasm. Back of the growing point the cells of the main axis of the gametophore and its branches are considerably larger, thicker walled, and more elongated in the longitudinal direction. The erect branches in *Climacium americanum* arise as lateral buds from procumbent runners or stolons. Field observations show that the stolon is merely an old gametophoric branch which has fallen over and given rise by lateral buds to new erect branches. This method of growth insures the spread of the moss and is evidently a factor of primary importance in its dissemination. The leaves of the moss plant lie appressed over all the upper portions of its branches. They are imbricated and by their overlapping completely sheath and enclose the growing points. In structure they are very simple being usually composed of a single layer of cells.

The moss gametophore hibernates in the green condition and is able to carry on its vital processes and to undergo appreciable growth during the winter. Plants have been dug from beneath the snow and ice in February, and the lighter green branches of the new growth are then already in evidence.

A longitudinal section of a gametophoric branch parasitized by Eocronartium shows that practically all the cells of the host are invaded by the mycelium, the hyphae running out into all the branches and entering many of the leaves (fig. 1). The mycelium permeates the host from the stolons to the apices of the branches, and is wholly intracellular. Normal

[5] Coulter, J. M., Barnes, C. R. and Cowles, H. C. A text book of botany for colleges and universities. Vol. 1, part 1. Morphology, p. 116.

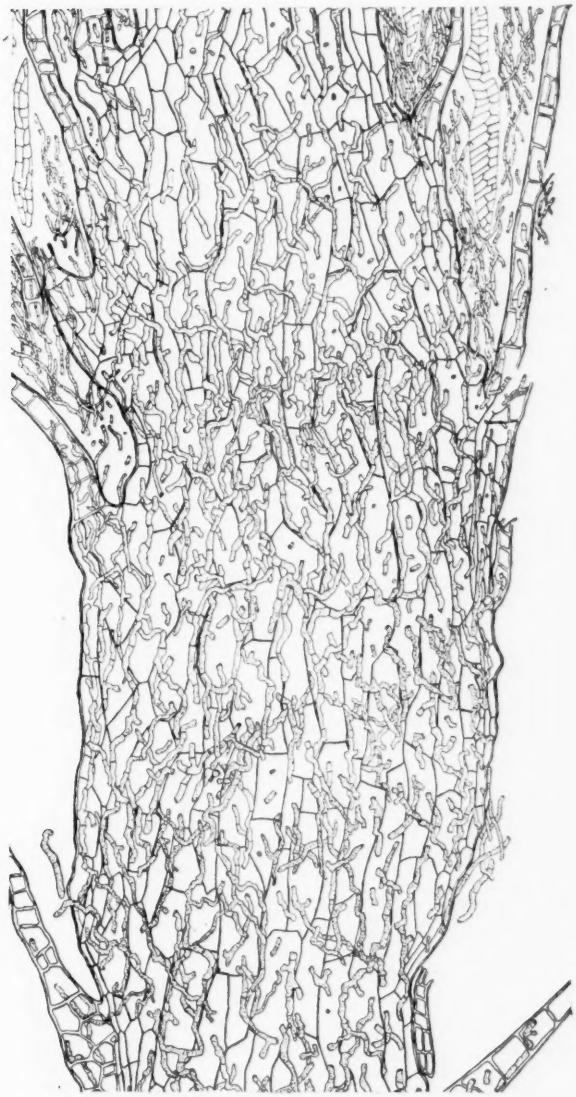

FIG. 1. MYCELIUM OF EOCRONARTIUM MUSCICOLA IN THE CELLS OF THE HOST

Longitudinal section of a branch of the gametophore of *Climacium americanum* showing the structure of the host and the character and amount of the endophytic mycelium. The portion of the host shown in the upper end of the section lies near the apical region. The hyphae which form the sporophore can be seen in the spaces between the overlapping leaves. The contents of the host cells are omitted to give greater contrast between host and parasite. Outlined with camera lucida. × 208.

intercellular spaces, as stated above, are absent in the moss gametophore, the cells lying tighly packed together with their walls united at all points. It might be expected that the hyphae of the fungus would under these conditions force their way between the cells by the excretion of an enzyme. Search through many sections has, however, failed to reveal even a single hypha in such an intercellular space. The hyphae pass directly from cell to cell through the intervening walls, and are constricted little if any in effecting penetration. Haustoria are not produced. An examination of a longitudinal section through the growing point at the apex of a gametophoric branch reveals the fact that many of the embryonic cells in this region are infested with the hyphae of the parasite.

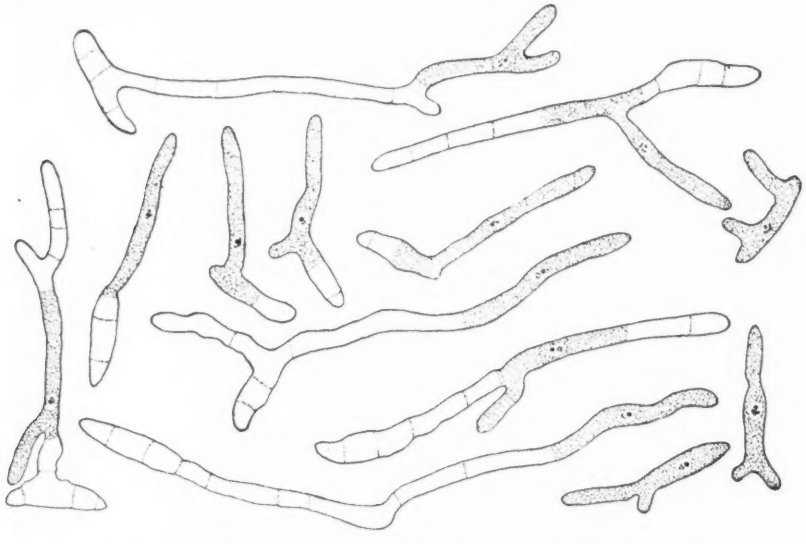

FIG. 2. GERMINATING SPORES OF EOCRONARTIUM MUSCICOLA

Stained with Haidenhain's iron alum-haematoxylin. The cross-walls are not true septa. Camera lucida. × 744.

In the early spring after the new lighter green branches have made their appearance on the moss plant, an examination of an infested individual shows the hyphae of the fungus in both the new and old growth. Since these hyphae traverse the cells of the developing branches, and later produce sporophores at their tips it is very evident that the fungus is perennial in the host and advances each year into the new growth.

The invaded host cells contain an apparently uninjured plasma membrane, abundant living protoplasm, and a normal nucleus (fig. 6). Longitudinal sections of healthy branches have been prepared, and a comparison of these with diseased material shows that no appreciable change results from the presence of the parasite.

THE ORIGIN AND STRUCTURE OF THE SPOROPHORE

Immediately preceding the development of the sporophore many of the hitherto endophytic hyphae in the apical region of the host pass out into the narrow spaces between the overlapping leaves and form there flat sheets of interwoven threads (fig. 1). These grow upward toward the tips of the leaves, and unite enveloping the growing point. This complex of interwoven filaments, now visible to the eye, elongates and develops rapidly into the young sporophore (fig. 7). Due to this method

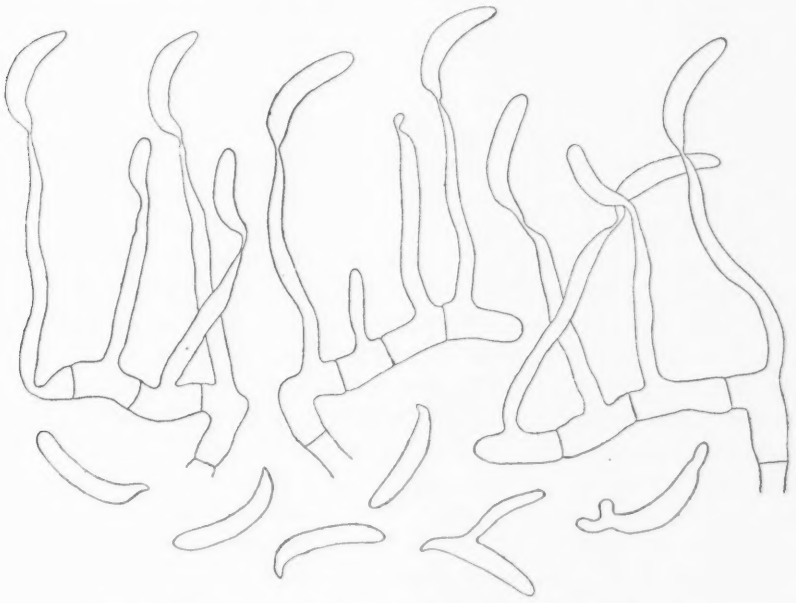

FIG. 3. BASIDIA AND SPORES OF EOCRONARTIUM MUSCICOLA

The spores do not mature simultaneously. Early stages in germination are shown below. Camera lucida. × 1078.

of development the base of the sporophore appears fibrillose spreading or in some cases definitely branched, while the upper portion may be deeply grooved (fig. 5). In some instances young sporophores originating at the apices of two or more different branches of the host may come into accidental contact and fuse completely, forming a single large sporophore with a prominently forked base. The sporophores in the majority of cases, however, remain separate, and a much branched gametophore may give rise to dozens of these, one from the apical region of practically every branch.

Occasionally the young sporogonium of the host begins its development before the hyphae of the fungus emerge to form the sporophore. In such cases the partially developed sporogonium is soon completely enclosed by the hyphae of the fungus and its further growth is arrested. Sections of the sporophore sometimes reveal such an immature sporogonium at its center. Since *Climacium americanum* rarely develops sporogonia this phenomenon has not, however, been noted in the case of this host.

Inclusions of bacteria, unicellular algae, uredospores and teleutospores of rust fungi, and conidia of Macrosporium have also been found in the interior of the sporophore. The presence of these foreign bodies is explained by the fact that the sporophore may remain quiescent during dry weather, and later during a rainy period undergo considerable elongation, enclosing material which has become attached to its surface. In protracted wet weather the growth of the hyphae may take place very rapidly, and the presence of water on the surface of the sporophore may result in the production of extremely abnormal forms due to the hyphae radiating out in all directions. The same phenomenon takes place when plants bearing sporophores are enclosed for a considerable period in a moist chamber. In normal specimens the mature fruit-body is clavate to cylindrical, and resembles that of a small unbranched species of Clavaria.

The hyphae composing the sporophore run chiefly in the longitudinal direction. They lie approximately parallel and do not branch or interweave to any extent. The basidia are formed over practically the whole surface of the fruit-body by the turning out at right angles of the ends of hyphae which lie at the periphery. The terminal cell of each of these hyphae then increases somewhat in diameter, and becomes a basidium. These basidia come to possess nuclei much larger than those of the vegetative cells, and more abundant granular cytoplasm. In the young condition they are short and clavate, but preceding spore formation they become greatly elongated, flexuous, and transversely septate into four cells (fig. 3). Each cell then gives rise to a long stout sterigma bearing a single, large, elongated to crescent-shaped spore. Although the hymenium is developed over practically the whole surface of the sporophore additional elongation under favorable weather conditions may take place, a sterile apical portion resulting. This region may later develop a hymenium. Basidia which lie near one another do not necessarily mature simultaneously, and sections of the sporophore usually show young and mature basidia side by side. The period of sporulation may extend over several weeks.

The resemblance of the fruit-body of Eocronartium to the teleutospore column of Cronartium was pointed out by Atkinson. The septate promy-

celia-like basidia radiating in every direction from the sporophore render the general appearance the same. It is this resemblance which led Atkinson to apply the name Eocronartium.[6]

Although a very careful search has been made for clamp-connections in this species none of these structures have been found. This fact is of interest in the light of their presence in the smuts and in many groups of the higher Basidiomycetes. Workers in general regard them as absent in the rusts, although Voss[7] has published figures purporting to show them in various genera of this group.

SPORE GERMINATION

In wet weather the spores of Eocronartium frequently germinate on the sporophore. They can be induced to germinate very readily in the laboratory in tap-water, practically 100 per cent germination being obtained in twenty-four hours. Germination takes place by the formation of germ-tubes which arise at any point on the surface of the spore, though more commonly at one or both ends. The production of secondary spores either on the spore or on the germ-tube has never been observed. Fusion between spores has not been noted. The protoplasm of the spore passes out into the germ-tube, and as the tube elongates passes into its tip (fig. 2). The spore as well as the lumen of the tube near the spore are thus soon emptied. False septa, probably composed of dried hyaloplasm, are formed at indefinite intervals as the protoplasm flows outward. After the germ-tube has attained a length several times that of the spore it ceases to elongate, and the protoplasm may retreat from its tip toward the spore leaving the end of the tube empty. A lateral branch may then be developed, the protoplasm passing into this. This process may be repeated several times until a considerably branched germ-tube results. In some cases the protoplasm passes back into the spore and from it into another germ-tube developed at some other point on its surface, thus leaving the first germ-tube empty. Finally the protoplasm becomes inactive, and no further development takes place.

The mature spore contains a single nucleus. This nucleus during spore germination migrates into the tube with the cytoplasm, but it has

[6] Saccardo (Sylloge Fungorum **17**: 211. 1905) characterizes this genus under the name Eucronartium. This error has already been called to attention by von Höhnel. The etymology (Eu-bene et Cronartium) given by Saccardo is evidently incorrect since this fungus is not a true Cronartium. It should be given Eos-primitivus et Cronartium.

[7] Voss, E. Über Schnallen und Fusionen bei den Uredineen. Ber. deut. bot. Gesell. **21**: 366–371. 1903.

never been seen to divide there. Although stained material of hundreds of germinating spores has been examined a germ-tube containing more than one nucleus has never been found. The writer in a preliminary note[8] published during the early stages of the investigation makes the statement that the binucleate cells arise in the germ-tube. This assertion is based on the fact that the mature spore is uninucleate while all the cells of the endophytic mycelium ever observed are binucleate. The conclusion that the binucleate condition arises in the germ-tube is consequently not illogical. The actual observation of binucleate cells in the germ-tube has never, however, been made.

Attempts to grow the fungus in pure culture have met with failure. Spores have been allowed to germinate in sterile distilled water, tap-water, solutions of cane sugar and glucose, and various synthetic solutions. They have also been germinated in water containing macerated moss leaves. They have been plated out on many different sorts of nutrient agar including several synthetic agars and moss decoction agar. A great variety of artificial culture media has, in fact, been used in the endeavor to induce the fungus to develop in pure culture at least to the extent of the production of a multinucleate germ-tube. The results resemble those obtained in the germination of spores of rust fungi, and would seem to warrant the conclusion that Eocronartium is an obligate parasite.

INOCULATION EXPERIMENTS

Since it has been impossible to grow the fungus in pure culture, it has been necessary to use suspensions of spores taken directly from the sporophore for inoculations. Extensive series of inoculations have been made in this way during the past two seasons. Diseased host plants bearing young sporophores have been brought in from the woods and placed in the greenhouse under as nearly natural conditions as possible. Here the fruit-bodies have completed their development and matured spores. By this method of procedure material of all ages has been easily obtained and abundantly sporulating fruit-bodies have been available. Healthy host plants for inoculation have also been collected in localities believed to be relatively free from the fungus. Since in diseased plants there is, preceding sporophore formation, no external evidence of the presence of the parasite, the host plants used for inoculations can not be demonstrated to be free from the fungus without a microscopic examination. Check material was, therefore, imbedded in paraffin, and stained. Healthy

[8] Fitzpatrick, Harry M. The parasitism, biology, and cytology of *Eocronartium typhuloides* Atk. Phyto. **4**: 407. 1914.

plants of a large number of species of mosses were collected, and used for cross inoculations. This list included known hosts of Eocronartium, and others upon which the parasite has not been reported, a total of twenty genera of mosses in ten families being represented.

In the inoculation work a number of different methods of procedure were employed. A drop of sterilized water was placed in the center of a sterilized slide, and a fruit-body was removed from the host and washed in this. Since the spores fall away readily this procedure resulted in a spore suspension containing hundreds of spores. This suspension was first examined microscopically to insure the presence of abundant spores, and was then pipetted in its entirety directly upon the portion of the host selected for inoculation. The inoculated branches were identified by enclosing each within a small glass ring. Both old and young host plants were inoculated. In some cases the branches selected were very young and embryonic. Certainly no single inoculation was made with fewer than several hundred spores. Host plants were inoculated in the field, in the greenhouse, and in the laboratory. In some cases they were placed after inoculation in darkness. In a few instances they were left exposed to the air, but in the majority of cases they were enveloped in a very humid atmosphere in closed moist chambers. Series of inoculations were made in which detached branches of the host were placed before inoculation between wet filter papers in closed petri dishes. The spores used were taken chiefly from sporophores produced on *Climacium americanum*. A considerable number of inoculations were, however, made with spores from *Amblystegium serpens* and *Brachythecium oxycladon*. Cross inoculations were made on *Climacium americanum* with spores from both of these hosts, and spores from *Climacium americanum* were placed on many mosses including known hosts of the parasite, e.g., *Thuidium delicatulum* and *Anomodon rostratus*.

Following inoculation branches were removed from the plants at twelve-hour intervals and placed in fixing solutions. This procedure was continued in some series for ten days. The material was all imbedded in paraffin and subsequently stained. Search was then made through all the preparations, but in no instance, was a single infection found to have taken place. This fact is difficult to explain in view of the large amount of inoculum used, and the variety of conditions under which inoculations were made. More time has been given to this phase of the problem than to any other, and publication has been delayed two years in the hope that infections might be obtained. It is evident that the optimum conditions for infection have not been attained. Although inoculations have not been made under carefully controlled conditions of temperature and humidity, a considerable range of temperature has existed in the

various series and sufficient moisture for spore germination has been provided. The suggestion that the species is heteroecious has been given consideration but no evidence bearing on this point has been obtained.

Since the possibility exists that infection takes place in nature only on the protonema, experiments were undertaken to test this point. *Climacium americanum* is unfavorable for this type of work because sporogonia are so rarely developed. Plants of *Brachythecium oxycladon* were collected, however, on which both sporogonia and fungous sporophores were being produced in abundance. The moss spores were removed from the capsules under as nearly aseptic conditions as possible, and mixed in a drop of sterilized water with spores of the fungus. This suspension of moss and fungus spores was then in some cases used in making smears on agar plates, while in other cases dilution plates were poured. Synthetic agar[9] of the following formula was used.

Agar	10.0 gram
NH_4NO_3	0.5 gram
$MgSO_47H_2O$	0.2 gram
K_2HPO_4	0.2 gram
$CaCl_2$	0.1 gram
$FeSo_4$	Trace
Distilled H_2O	1000 cc.

At the end of twenty-four hours the spores of both the fungus and the moss had germinated, and protonemal threads several times the diameter of the spore in length had developed. These continued to grow and in some instances came into direct contact with the fungous germ-tube. Although they were observed closely for several days, in no case, however, did a germ-tube penetrate a protonema, nor did those germ-tubes in the immediate vicinity of a protonema seem to be attracted toward it. Neither the moss nor the fungus were obtained in pure culture and after a week the plates were discarded.

Certain field observations made by the writer have a bearing on the problem of infection. In a large wood lot near Ithaca *Climacium americanum* is very profuse in its development, and patches of this moss 6 or 8 feet in diameter are numerous. Some of these patches are severely affected with Eocronartium and bear hundreds of sporophores. Other patches of the same species distant only a few yards seem to be wholly free from the fungus, search failing to disclose even a single fruit-body. It will be recalled that this species of moss spreads vegetatively from year to year by stolons, and depends little on spores for its dissemination. This

[9] Schramm, J. R. Some pure culture methods in the algae. Ann. Mo. Bot. Gard. **1**: 23–45. 1914.

fact taken in connection with the perennial nature of the parasite and the existence of large apparently uninfected patches of the moss in close proximity to diseased ones may possibly mean that the spores of the fungus have in nature ceased to cause infection, or do so only under certain very special conditions.

The size of the sporophore of Eocronartium varies greatly on different hosts and is apparently dependent on the size of the plant attacked. A large moss like *Climacium americanum* bears sporophores commonly 2 cm. in length (in rare cases as much as 6 cm.), while the fruit-bodies developed on a small moss like *Amblystegium serpens* are relatively minute. This difference in size is a natural result of the difference in quantity of the nutritive mycelium and of the food material available.

Since a critical microscopic examination of the fungus from various mosses fails to reveal any difference in the character of the mycelium, basidia, or spores it is probable that there is present only a single somewhat variable species.

NOMENCLATURE

The description of *Clavaria muscicola* given by Persoon[10] is apparently the first reference made in literature to a Typhula-like fungus parasitic on moss. As described by him the fruit-body is slender, unbranched, and characterized by the possession of a distinctly bulbous base. This bulbous base is figured by Persoon[11] and later also by Nees von Esenbeck[12] (fig. 4). This enlargement is not, however, a definite sclerotium as would be expected in a species of Typhula. It consists merely of a somewhat indefinite swelling at the base of the sporophore at the point of attachment to the host.

Fries[13] describes what he regards as the same fungus under the name *Pistillaria muscicola*. He states, however, that he has not observed the swollen base, his own plants at the point of attachment to the host being fibrillose spreading. He evidently believed that this character constitutes merely a variation within the species since he uses the specific name applied by Persoon, cites the binomial of Persoon as a synonym, and refers to the figures of Persoon and Nees von Esenbeck both of which illustrate the fungus with the bulbous base.

[10] Persoon, C. H. Synopsis methodica fungorum, p. 606. 1801.

[11] Persoon, C. H. Observationes Mycologicae. Usteri's Annal. d. Botan. **16:** pl. 3, fig. 2. 1795.

[12] Nees von Esenbeck, C. G. Das System der Pilze und Schwamme, pl. 16, fig. 154. 1816.

[13] Fries, Elias. Systema Mycologicum **1:** 498. 1821.

Later Karsten[14] describes as *Clavaria muscigena* a fungus occurring on *Climacium dendroides* in Finland. It resembles closely the fungus of Persoon but lacks the swollen base. He states that it may be only a variety of Persoon's species lacking this character.

Fries[15] in 1874 after receiving from Karsten specimens of *Clavaria muscigena* announces them to be identical with his own species which he now terms *Typhula muscicola*. Fries had apparently never seen specimens of the fungus of Persoon, and he now says that *Clavaria muscicola* may after all prove to be a different fungus.

Karsten[16] later in a discussion of his fungus states that it is identical with *Clavaria uncialis* Greville,[17] the latter plant differing, according to him, only in its occurrence as a saprophyte.

FIG. 4. SPOROPHORE OF CLAVARIA MUSCICOLA

Reproduction of the figure (pl. 16, fig. 154) given by Nees von Esenbeck, and cited by Fries. The bulbous base described by Persoon is shown. The size of the original figure is maintained.

None of these workers mention in their descriptions more than the most evident external characters of the fruit-body. The statement by Quelet,[18] that in specimens of *Clavaria muscicola* collected by him in France the spores are fusoid or vermiform, is the only reference made to the microscopic characters of a Typhula-like fungus parasitic on moss, by any worker, so far as the writer is aware, preceding the investigation by Atkinson. Quelet does not describe the basidia and merely assumes that they are similar to those of other species of Clavaria and Typhula.

Atkinson's discovery of the transverse septation of the basidia in American material previously called *Typhula muscicola*, and the consequent erection of the genus Eocronartium, was followed by the statement from von Höhnel that a critical examination of European material of *Clavaria muscigena* shows this species to be also Eocronartium. These results have raised the question whether *Clavaria muscicola* Persoon, *Typhula muscicola* Fries, *Clavaria muscigena* Karsten, *Clavaria uncialis* Greville, and *Eocronartium typhuloides* Atkinson are not all identical. The writer has endeavored by the microscopic examination of all available material to determine this point, and to learn if possible whether there exists any species of Typhula parasitic on moss.

[14] Karsten, P. A. Notiser Fauna et Flora Fennica. **9**: 373. 1868.
[15] Fries, Elias Hymenomycetes Europaei, p. 684. 1874.
[16] Karsten, P. A. Mycologia Fennica. Part 3. Basidiomycetes, p. 338. 1876.
[17] Greville, P. K. Scottish Cryptogamic Flora **2**: pl. 98. 1824.
[18] Quelet, L. Flore Mycol. de la France, p. 458. 1888.

Through the courtesy of Professor O. Juel, curator of the herbarium of Fries at Upsala, Sweden, it has been possible to examine the material with which Fries and Karsten actually worked. In the herbarium at Upsala there are only three collections of *Typhula muscicola*. One of these is exsiccati material from Rabenhorst's Fungi Europaei. The two others are a part of the private herbarium of Fries. The packets bear no identifying numbers. The data accompanying them are as follows:

Clavaria muscicola from Nerike (in the center of Sweden) collected by Baron Wrangel and sent to Wahlenberg in 1810. On *Leskea polyantha*.

Typhula muscicola Fr. on *Climacium dendroides*, collected August 2, 3, 1869, by P. A. Karsten.

The first of these specimens is certainly the type upon which Fries bases his description of *Pistillaria muscicola* in Systema Mycologicum, because in this publication he refers only to the specimens of Persoon which he had not seen, and to those in his own herbarium collected on *Leskea polyantha* in Sweden by Baron Wrangel.

The second specimen is that on which Fries in Hymenomycetes Europaei bases his statement that *Clavaria muscigena* is identical with *Typhula muscicola*. It seems certain that this specimen is the same as that on which Karsten founded his species, since in Mycologia Fennica he mentions only one Typhula-like fungus on moss and the species of the host (*Climacium dendroides*) is the same in both cases.

The writer received only a single sporophore of each of these two collections, but a careful microscopical examination proves them to be the same, and also demonstrates beyond all doubt that both of these fungi are identical morphologically with *Eocronartium typhuloides*. They possess the same transversely septate basidia, and the same elongated to crescent-shaped spores. The measurements in all cases are practically alike. It is evident, therefore, that *Typhula muscicola* Fries, *Clavaria muscigena* Karsten, and *Eocronartium typhuloides* Atkinson are identical. It remains only to be demonstrated whether *Clavaria muscicola* Persoon and *Clavaria uncialis* Greville are the same.

The writer wrote to the herbarium of Persoon at Leiden, Netherlands, asking to be allowed to examine a fragment of the type material of *Clavaria muscicola*. W. A. Goddÿn the curator has been unable, however, to find a specimen of this species entered in the herbarium as Clavaria, Pistillaria, or Typhula. He has very courteously written to this effect and adds: "In all probability there have never been specimens of this species in the herbarium of Persoon." Since it is highly improbable that authentic type material of this species exists in any herbarium in the world it will never be known with absolute certainty to what form Persoon

applied the name *Clavaria muscicola*. Consideration of the great variation in the shape of the sporophore of Eocronartium has, however, led the writer to the conclusion that unwarranted emphasis has been laid on the bulbous base described by Persoon. Berkeley[19] describes sporophores of *Typhula muscicola* with forked tips, and the writer has, as previously stated, not only produced extremely abnormal fruit-bodies in enclosed moist chambers but in nature also has found the greatest variation both in shape and size. Bearing in mind the high degree of parasitism exhibited by Eocronartium it is reasonably safe to assume that Persoon's species is the same.

Since the specific name used by Persoon is the same as that of Fries, inability to study the type material of Persoon has fortunately no bearing on the selection of the correct name for this species. The specific name *muscicola* must be retained. The synonomy may be given as follows:

Eocronartium muscicola (Fr.) comb. nov.

Syn. *Clavaria muscicola* Pers. Syn. Meth. Fung. pp. 606, 1801.
Pistillaria muscicola Fr. Syst. Mycol. **1:** 498. 1821.
Typhula muscicola Fr. Epicr. Syst. Mycol. pp. 585. 1838.
Clavaria muscigena Karst. Not. Faun. et Fl. Fenn. **9:** 373. 1868.
Eocronartium typhuloides Atk. Jour. Mycol. **8:** 106–107. 1902.
Eocronartium muscigena (Karsten) von Höhnel. Sitzber. K. Akad. Wiss. Wien. **118**[2]**:** 1461–1552. 1909.

Microscopic examination of all the herbarium material of *Eocronartium muscicola* at the New York Botanical Garden and at Cornell University shows a close agreement in the measurements of the spores and basidia; and it is evident that only a single species is represented.[20] The following exsiccati specimens have been studied.

Rab. Fung. Europ. No. 417, No. 1327.
E. &. E. N. Am. F. 2nd ser. No. 2320.
E. & E. Fungi Columb. No. 1687.
Ravenel Fungi Carol. Exsic. Fasc. 3, No. 36.

Karsten's assertion that *Clavaria muscigena* is identical with *Clavaria uncialis* is evidently based either on a superficial examination of the two fungi or on a comparison of his material with the description and figures of

[19] Berkeley, M. J. Notices of North American Fungi. Grevillea **2:** 18. 1873.
[20] A specimen from the herbarium of Ravenel which is in the British Museum was made available to me by Professor H. H. Whetzel who obtained a fragment through the courtesy of J. Ramsbottom, the curator.

Greville. He records no microscopic examination of either fungus. *Clavaria uncialis* occurs as a saprophyte on the decaying stalks of herbaceous plants and has not been reported as occurring on moss. The sporophores are described by Greville as "white, gregarious, round, club-shaped, smooth, not fragile, rounded at the apex, below naked, much attentuated." They thus resemble superficially certain specimens of *Eocronartium muscicola*. A microscopic examination, however, proves the two fungi to be very different. The consistency of the fruit-body in *Clavaria uncialis* lacks entirely the semi-gelatinous character of *Eocronartium muscicola*, and the hyphae composing it are of much smaller diameter. The hymenium, unlike that of Eocronartium, is sharply differentiated from the trama and is made up of short, clavate basidia. The figure given by Greville showing a section through the hymenium represents well the general appearance. The basidia are non-septate, produce minute sterigmata at the apex, and bear small, ellipsoidal spores. The writer has examined authentic material from the two following European collections of this species. The type has not been available.

C. uncialis Grev. Roumeguère Fungi Selecti Galliaei Exsiccati No. 108 on dead stems of *Sonchus sp.* Vosges Mountains, France.

C. uncialis Grev. specimen from private herbarium of G. Massee deposited at the New York Botanical Garden; on dead herbaceous stems.

OTHER PARASITIC AURICULARIACEAE

The literature of the Auriculariaceae is widely scattered, and much of it not readily available. It has seemed desirable, therefore, that the published facts bearing on the phenomena of parasitism in this group should be brought together. Although many species of the family are saprophytes a careful review of literature reveals the fact that the group contains a considerable number of species in which parasitism is well developed. There are also many species now said to be saprophytic which on careful investigation may prove to be parasitic. This is particularly true of the little known tropical species.

The genus Jola is especially interesting, and it is desirable that its species be studied carefully. Several of these have been described as parasitic on mosses, and form their fruit-bodies on the calyptra and stalk of the sporogonium. Moller[21] founded the genus on *Jola Hookeriarum* which he describes as a true parasite on *Hookeria albata* and *H. jungermanniopsis* in Brazil. According to his account the mycelium of the

[21] Möller, Alf. Protobasidiomyceten-Untersuchungen aus Brasilien. Botanische Mittheilungen aus den Tropen von Schimper. **7**: 1–175, pls. 1–6. 1895.

fungus fills the capsule and prevents the formation of spores. Patouillard[22] describes two additional species, *Jola javensis* and *J. mahensis*, but does not state that they are parasitic. He merely records their occurrence on the calyptra of certain mosses. Later Lagerheim[23] describes a fourth species, *J. Lasioboli*, on the hymenium of *Lasiobolus equinum* (Müll.) Karsten, a Discomycete. Although he made no effort to demonstrate its parasitism the presence of its mycelium in the hymenium of the Discomycete, and the fact that other species of cup fungi near by were not attacked seemed to show that it is a true parasite with a definite host.

Raciborski[24] described from Java a disease of *Acrostichum* (*Hymenolepis*) *spicatum*, a member of the Polypodiales, due to the parasitism of *Platygloea Hymenolepidis*. The spores of the fungus germinate on the upper surface of the young leaves, and the germ-tubes penetrate directly into the epidermal cells, developing there a branching mycelium. Following the general infestation of the epidermal cells hyphae push out in great numbers to the surface of the leaf and are there embedded in a gelatinous matrix which covers the leaf as a slimy coating. Numerous cork-screw shaped haustoria enter the subepidermal cells and the mesophyll cells are much hypertrophied. The diseased leaves become noticeably twisted and distorted.

Lind[25] made a careful study of *Gloeosporium filicinum* Rostrup (*Exobasidium Brevieri* Boudier), the cause of a common and well known disease of the fern, *Asplenium felix-femina* in Europe, determined it to be a member of the Auriculariaceae, and named it *Herpobasidium filicinum* (Rostr.)Lind. He also studied its relation to the host and found it to be a well-developed parasite. The fungus produces prominent whitish spots on the lower surface of the frond similar to those caused by Exobasidium. The hyphae invade all parts of the host and apparently hibernate as perennial mycelium in the rhizome. Cork-screw shaped haustoria are produced in the host cells, and knarls of hyphae are formed in the sub-stomatal chambers. Preceding basidium formation the lower epidermis is ruptured, and the hymenium is developed on the surface of the host. The basidium which is irregular in shape, and transversely septate into only two cells is evidently of a primitive type and not characteristic of the Auriculariaceae.

[22] Patouillard, N. Note sur trois Heterobasidies muscicoles. Bul. soc. mycol. Fr. **13**: 97–100. 1897.

[23] Lagerheim, G. Mycologische Studien III Bih. K. Sv. Vet. Handl. **24**: No. 4. 1899.

[24] Raciborski, M. Nalistne i pasorzytne grzby Jawy-Parasitic and epiphytic Pilze Java's. Bul. Inter. de l'Acad. des Sci. de Cracovie, pp. 346–394. 1909.

[25] Lind, J. Sur le developpement et la classification de quelques especes de Gloeosporium. Arkiv. för Bot. **7**: No. 8. 1–23, pls. 1–3. 1908.

Tanaka[26] has discovered a disease of the mulberry tree caused by a member of this family. The fungus which he names *Helicobasidium mompa* attacks the roots of living trees after the manner of *Armillaria mellea*. These die and the growth of the shoots is arrested, the leaves developed being smaller than normal and finally dying. Rhizomorphs are produced which penetrate the bark and spread widely in the cambium and bast, girdling the root. The girdling results in the production of new roots above. The mycelium forms enormous numbers of sclerotia in the diseased tissues, and fruit-bodies are developed on the surface of the host just above ground.

Bourdot and Galzin[27] state that a fungus which they have named *Platygloea Peniophorae* is parasitic on the hymenium of *Peniophora pubera* and *Gloeocystidium praetermissum*. Their account, however, contains no discussion of the nature of its parasitism.

The "Jew's Ear" fungus is described as parasitic by LeGoc.[28,29] He germinated spores and obtained pure cultures on agar, gelatine, and sterilized blocks of wood of elder, lime, and elm. Inoculations made with mycelium and spores from culture on living branches of elder were successful. Cuts the thickness of a finger were made in the bark, and in these were placed a few threads of mycelium or drops of water containing a suspension of spores. The wounds were then wrapped with foil. Although penetration was slow infection finally resulted. After several months the tissue near the point of inoculation was killed and later the branch died.

Septobasidium pedicellatum has been described as parasitic on pear, apple, and other trees by various workers.[30] The exact nature of its parasitism has not been well understood. Burt[31] discusses seventeen species of this genus in his monograph of the species of North America and the West Indies, and his observations concerning their biology are interesting. He states that although all the species known to him occur on living branches or leaves, in no instance has he seen penetration of the epidermis or bark by the fungus nor any injury, deformation, or gall

[26] Tanaka, N. A new species of hymenomycetous fungus injurious to the mulberry tree. Jour. Col. Sci. Imp. Univ. Japan Tokyo **4:** 193–204, pls. 24–27. 1890.

[27] Bourdot, H. and Galzin, A. Hymenomycetes de France. I Heterobasidies. Bul. Soc. Mycol. Fr. **25:** 15–37. 1909.

[28] Le Goc, M. J. Observations on *Hirneola auricula-judae*. Proc. Cambr. Phil. Soc. **17:** 225–228. 1913.

[29] Le Goc, M. J. Further observations on *Hirneola auricula-judae* Berk. ("Jew's Ear") New Phytologist **13:** 122–133, figs. 1–9. 1914.

[30] Galloway, B. T. A new pear disease. Jour. Mycol. **6:** 113–114. 1891.

[31] Burt, E. A. The Thelephoraceae of North America, VII, Septobasidium. Ann. Mo. Bot. Garden **3:** 319–343, figs. 1–14. 1916.

response by the branch or leaf. He states that the fructifications of these fungi are commonly associated with colonies of scale insects. Petch[32] has given this phase of the subject careful attention, and he says that the species of Septobasidium are in reality parasitic on the scale insects, and that they overgrow and completely destroy these. The fungi are not, as in certain other cases, found on the insect excreta, but on the insects themselves.

A considerable number of species of Auriculariaceae have been reported as occurring on living hosts though not actually proved to be parasitic. These species have been described in the genera Septobasidium, Jola, Saccoblastia, Helicobasidium, Ordonia, and Mohortia.

A survey of what is known concerning the phenomena of parasitism in this family reveals certain outstanding features which should be called to attention. The above review shows that species of Auriculariaceae are parasitic on fungi, mosses, ferns, flowering plants, and insects. It is evident also that there exists in the family a wide variation in the relation between fungus and host extending from saprophytism to obligate parasitism. It will be noted moreover that in this group the number of established cases of parasitism on mosses and ferns exceeds the number on flowering plants. This is especially noteworthy since mosses and ferns serve as hosts for relatively few parasitic fungi.

PHYLOGENETIC CONSIDERATIONS

The fact that parasitism in the Uredinales is in all cases obligate makes it logical to suppose that these fungi arose from less highly specialized parasites of ancient origin. If the parasitism of the rust fungi were a recent development we might reasonably expect to find in the group tendencies toward facultative parasitism. Grove[33] in a discussion of the phylogeny of these fungi reasons as follows: "In the first place, their strict parasitism implies a very close adaptation between them and their hosts: this is not only *a priori* probable, but is confirmed by culture experiments and the existence of biological races. Therefore, those which are parasitic on the lowest hosts must be, on the whole, most similar to the primitive forms, and those parasitic on the higher families would be expected to show the greatest advance. This consideration alone is sufficient to determine that Uredinopsis is like one of the primitive Uredinales and that the genera Puccinia and Uromyces contain the highest

[32] Petch, T. Note on the biology of the genus Septobasidium. Ann. Bot. **25**: 843. 1911.

[33] Grove, W. B. The British Rust Fungi (Uredinales) Their Biology and Classification. Cambridge Univ. Press. 1913.

types. For Uredinopsis grows upon Ferns, and more than a quarter of the Pucciniae live on the Compositae."

A critical examination of the classification of the Uredinales reveals in fact that the species of many of the primitive genera of the group occur in at least a portion of their life cycle on ferns or gymnosperms, while genera showing a higher advance in morphology tend to be restricted to hosts in higher orders. A detailed discussion of the evolution of the Uredinales, and a consideration of the origin of heteroecism will not be entered into here. These phases of the subject have been sufficiently treate l by others.[34,35] A suggestion concerning the bearing of the investigation of *Eocronartium muscicola* on the origin of the rust fungi may, however, be desirable. Admitting that the rust fungi on ferns constitute a primitive type, it is carrying the argument only one step farther to suggest that the ancestors of these forms occurred on mosses. The Uredinales probably arose from forms similar to those now embraced in the Auriculariaceae, their high degree of specialization having resulted from their parasitic habit. The existence of a number of parasitic species of Auriculariaceae on mosses, and the presence in *Eocronartium muscicola* of a highly developed obligate parasitism suggest the origin of the Uredinales from this group.

The line of separation between the Uredinales and Auriculariaceae is not sharp. The cell which gives rise to the basidium in the Auriculariaceae is homologous with the cell of the teleutospore of the Uredinales and there exist in the genera Septobasidium,[36], Jola,[37,38] Saccoblastia, Ordonia, and Mohortia transition stages in the development of the teleutospore from the young basidium. Raciborski[39] describes in *Ordonia orthobasidion*, an epiphytic species, the production of thick-walled, brown, resting teleutospores which on germination produce a typical promycelium. The existence of similar, though less highly developed, structures in the genus Jola, and their total absence in Eocronartium indicates that the species of Jola lie nearer the rust fungi than does Eocronartium. The

[34] Grove, W. B. The evolution of the higher Uredineae. New Phytol. **12**: 89–106. 1913.

[35] Olive, E. W. Origin of heteroecism in the rusts. Phytopath. **1**: 139–149. 1911.

[36] Patouillard, N. Septobasidium, noveau genre d'Hymenomycetes heterobasidies. Jour. Bot. **6**: 61. 1892.

[37] Patouillard, N. Note sur trois heterobasidies muscicoles. Bul. soc. mycol. Fr. **13**: 97–100. 1897.

[38] Lagerheim, G. Mycologische Studien III Bih. K. Sv. Vet. Handl. **24**: No. 4. 1899.

[39] Raciborski, M. Nalistne i pasorzytne grzby Jawy-Parasitic and epiphytic Pilze Java's. Bul. Inter. de l'Acad. des Sci. de Cracovie, pp. 346–394. 1909.

investigation of one of the species of Jola which occur on moss, and the demonstration in it of obligate parasitism would be extremely interesting in this connection.

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PLATE I

FIG. 5. SPOROPHORES OF EOCRONARTIUM MUSCICOLA ON CLIMACIUM AMERICANUM

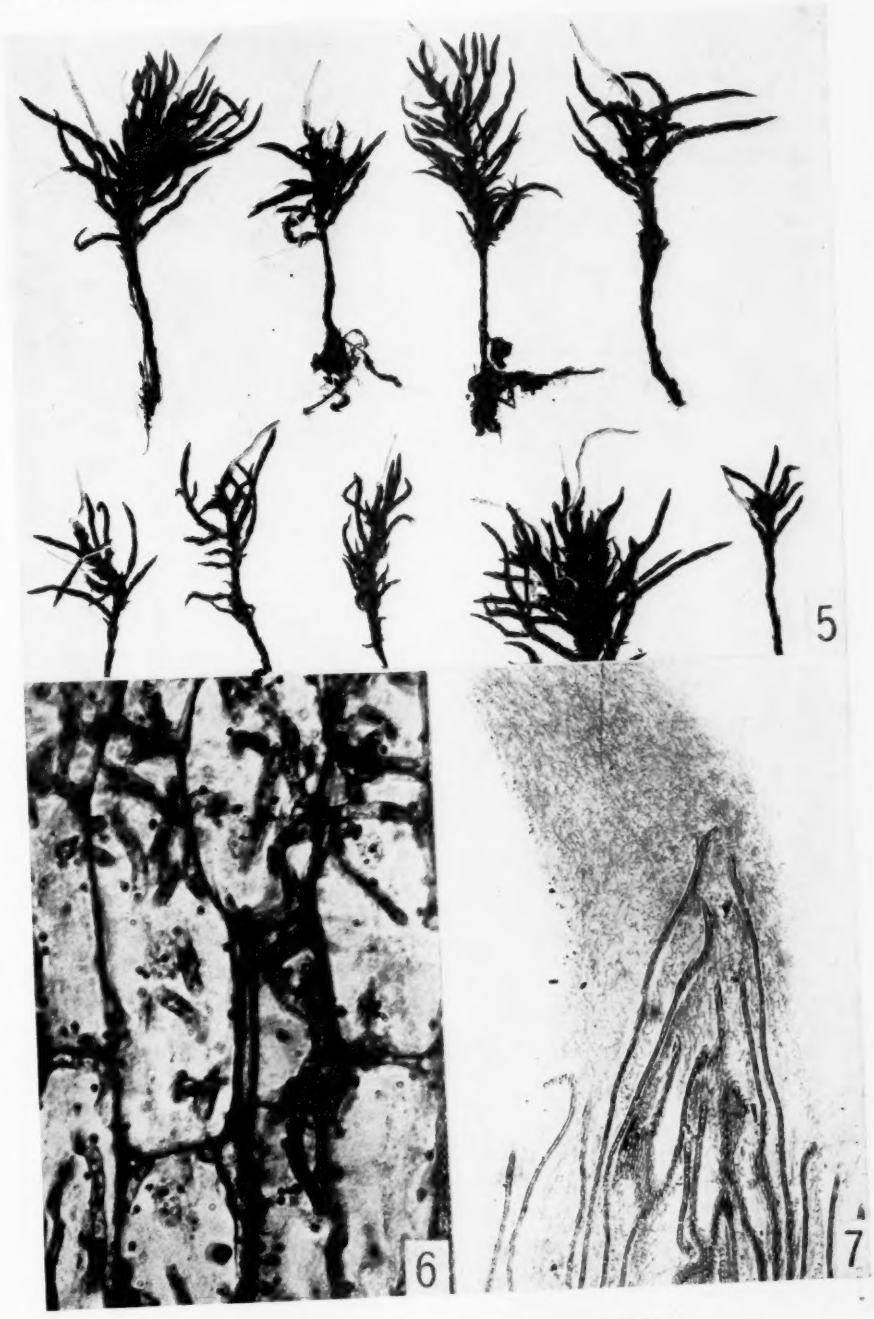
Natural size.

FIG. 6. HYPHAE OF EOCRONARTIUM MUSCICOLA IN LIVING CELLS OF THE HOST

Photomicrograph of an inner portion of a longitudinal section of an erect gametophoric branch of *Climacium americanum*. Compare with figure 1. Here the host nuclei and cytoplasm are evident. The hyphae lie inside the cells. × 672.

FIG. 7. SPOROPHORE OF EOCRONARTIUM MUSCICOLA ARISING FROM THE APICAL REGION OF A GAMETOPHORIC BRANCH OF CLIMACIUM AMERICANUM

Photomicrograph of a longitudinal section showing the leaves overlapping above the growing point. The mycelium of the fungus is seen passing up between the leaves and converging to form the sporophore. × 72.



FITZPATRICK: EOCRONARTIUM MUSCICOLA

THE RELATION OF PHYTOPATHOLOGISTS TO PLANT DISEASE SURVEY WORK[1]

G. R. Lyman

The work of plant pathology falls in three categories, each of which is coming more and more to require the services of specially trained experts. The first of these is research on the nature and development of the disease and the effect upon the host plant. The goal of phytopathological research is the discovery of effective methods of controlling in the field the disease under investigation. The second division of pathological work is extension,—which carries to the grower the results of research work, and demonstrates to him the practical control of plant diseases. This important work, which was formerly carried on by the research pathologist as a subordinate part of his activity, is being rapidly developed and given over more and more to extension specialists.

A third branch of phytopathological work is now beginning to be recognized—the intelligence service, or the systematic gathering of field data on plant diseases. Both research and extension work are based on field study of the diseases, and the gathering of such information must precede and accompany all other pathological activity. In the past there has been little systematic survey work, the research and extension workers undertaking only as much as was absolutely necessary to the prosecution of their main projects. But the increasing importance of phytopathological work makes necessary a more efficient intelligence service, and since the collecting and correlating of field data present special problems, it follows that in the future the work must be placed largely in the hands of plant disease survey experts, who with the research and extension pathologists, complete the trio of phytopathological specialists.

Plant disease survey work was begun in the United States Department of Agriculture a number of years ago, but only last July was it given recognition as an independent enterprise, with an opportunity to work out its own problems. In formulating our plans for developing the Survey we must keep clearly before us the fact that plant disease survey work is public service work. Plant diseases, on account of the havoc

[1] Paper read January 1, 1918, at the Pittsburgh meeting of the American Phytopathological Society in joint session with the Botanical Society of America and Section G of the American Association for the Advancement of Science in a symposium on Phytopathology in Relation to War Service.

wrought, are of vital concern to the public, and we must handle disease data as we would handle other public property, collecting and distributing them for the good of all. We must strive to serve all parts of the country, to benefit all pathologists, and to assist all pathological work, not advancing any individual or group of individuals by the exploitation of others. In this work we are not introducing new machinery to displace or to compete with that now existing. On the contrary we propose to coöperate with all agencies now working along this line, coördinating their work, and supplementing and assisting them wherever possible. In pursuance of this policy the pathologists at the experiment stations have been made plant disease survey collaborators and are now acting as local leaders in every state but one, a state in which pathological work has not been developed. Since taking up this work last spring I have been greatly impressed with the spirit shown by these men who are the leaders in phytopathology in their respective states, with their earnest desire for coöperation in working out our problems, with the absence of unfriendly and destructive criticism, and with their enthusiastic belief in the importance of Survey work as it is to be developed in the future. We have many problems to solve,—questions of finance, of personnel, of adjustment to other lines of activity, which must be taken up in each state, but we are not, so far, confronted with difficult problems of clashing interests and jangling personalities. I believe we shall avoid these pitfalls, and if we do we shall certainly be able to develop a service of very great value to phytopathology in the United States, and one which shall serve as an object lesson in botanical coöperation and a stimulus to similar efforts elsewhere.

Before passing to a discussion of our plans of organization let us briefly consider how we expect plant disease survey work to benefit pathologists in order that the character of our aims may be better understood and the scope and details of our plans be of greater interest. It is the function of the Plant Disease Survey to gather information on plant diseases, not to investigate the diseases themselves nor to demonstrate their control. Therefore, we shall not compete with the research pathologist or the extension worker, but shall coöperate closely with both by supplying the former with data necessary to the solution of his problems, and the latter with information which will aid him in planning and carrying out his campaigns. We propose to do this by systematizing the collecting and distributing of information, thus making the data more complete, more authoritative and more timely.

In the first place we hope to assist the pathologist in selecting the most important problems for study. Every pathologist, no matter where he may be located, has a multitude of problems pressed upon him for atten-

tion. Which shall he take up first? Especially embarrassing is the case of a newcomer beginning his duties as pathologist in a state or region, who finds no large body of accumulated data to guide him in orienting himself. What things are apt to influence or even to force his choice of problems? Too often it may be purely local conditions. Diseases of merely local prominence may assume an undue importance on account of lack of data to furnish a true perspective. Or it may be his choice is due to the persistence of certain persons in bringing particular diseases to his attention or to the finding of equipment at hand suitable for certain lines of work. All too frequently his personal inclination toward a certain problem or his previous training and experience govern his choice. All these points should receive due consideration, but the more vital questions are: what diseases are most important in this region or state, all things considered? In connection with what diseases will the greatest saving be made if control measures are discovered? Which are the problems most immediately important under the present war conditions? To properly answer these questions and to choose his problems wisely the pathologist must have access to a large body of plant disease data which will give him a grasp of the disease situation not only in his own state, but also in neighboring states, in order that the relations of his local problems to the broader ones of the nation may be understood.

I have talked with pathologists of many states this season and a number have frankly stated that the diseases they are investigating are probably of minor importance, but that a wiser selection is rendered difficult or impossible through lack of field data. The Plant Disease Survey must secure these data, thus clarifying the disease situation in each state, and delimiting the pressing problems. This service would be important in times of peace, but is imperative now in times of war, when, with our numbers reduced by military service, we must make sure that we are wasting no time on problems of lesser importance.

The Plant Disease Survey will also assist the pathologist in the prosecution of his research work. He needs detailed information on the nature and characteristics of the disease as they appear in the field, on the various factors influencing its development, on geographical and seasonal variation, on the methods and conditions of its spread from place to place. These and other data should be gathered by the Plant Disease Survey, working in many cases under the immediate direction and supervision of the investigator in order that he may obtain the exact information desired. Every pathologist should himself perform a sufficient amount of field work to thoroughly familiarize himself with every phase of his problem, and certain data of a highly technical character can be obtained by no one else, but for the skilled investigator to personally accumulate

the large body of field data which is frequently necessary is undoubtedly in many cases a serious waste of valuable time which could more profitably be spent on research. On the other hand, for him to attempt to solve his problem without adequate data may lead to serious error. Neither plan makes for efficiency. Close coöperation between the investigator and the Plant Disease Survey in accumulating these data is a businesslike division of labor, for the investigator's time can thus be conserved for research, and the gathering of data be placed in the hands of those trained for this work.

The Survey will aid the pathologist and the extension worker in planning and in carrying out their campaigns for disease control. In order that they may plan wisely they must know where the disease under consideration is most serious and its relative prevalence in different regions. They must know in what localities control measures are already generally practiced and where they are neglected in order to decide where demonstrations and educational work are most needed.

An efficient watch service on the health of plants developed by the Plant Disease Survey in close coöperation with the various agencies charged with disease control would be of immense value and would tend to conserve the health of our food crops as the Public Health Service conserves that of human beings. Early warning of impending outbreaks of disease would permit the immediate use of preventive measures which might check the development of serious epidemics. Prompt notification of the first appearance each season of serious diseases which are susceptible of control, like late blight of potato, is the first prerequisite for effective control of these diseases. Careful accumulation of field data on epidemics and on unusual occurrences of important diseases would lead to a better understanding of the conditions influencing the development, spread and control of such outbreaks.

The Plant Disease Survey should also maintain a watch for new diseases which have gained a foothold in the United States and for new and virulent strains of old diseases in order that early warning may be given to plant pathologists and data furnished the Federal Horticultural Board on which quarantines to prevent the spread of the diseases may be based. Pathologists are engrossed in their work and new diseases are apt to escape observation or to be disregarded until they have so thoroughly established themselves and spread over such a wide area that their eradication becomes almost, if not quite impossible. Our chestnut trees are being destroyed by the chestnut blight, a new disease which thoroughly established itself and spread beyond control throughout the region around New York City before it was discovered. The white pine blister rust remained undiscovered for four or five years, and might have remained

still longer in obscurity if attention had not been directed to it by its appearance in the nursery of one of the experiment stations. Citrus canker, which has already cost many hundred thousand dollars of state and federal funds in efforts to eradicate it and has caused great loss to citrus growers in the gulf states, spread from Texas to Florida before it was discovered.

Not only should a constant watch be kept for new and dangerous diseases, but these diseases when located should immediately be given intensive field study in order that their distribution, hosts and importance may be determined and repressive measures promptly adopted. Otherwise history shows that there will inevitably intervene a long period of inaction following the discovery of the disease, during which evidence slowly accumulates which finally rouses public sentiment in favor of eradicatory measures. During this time of inaction the disease spreads beyond possibility of control if it was not already so when discovered. The Plant Disease Survey organization should undertake this preliminary field investigation, accumulate evidence as to the character of the disease, and take the lead in publicity work, until such time as state and federal pathologists are prepared to take charge of the work. If there had existed a well organized and efficient Plant Disease Survey some years go it is probable that such diseases as chestnut blight, white pine blister rust and citrus canker would have been discovered more promptly and their importance recognized more quickly, thus materially increasing the chances for their eradication.

The Plant Disease Survey should also study the geographical distribution of diseases in the United States, a field of work not now sufficiently cultivated. Diseases of limited distribution should be carefully scrutinized, especially if they are found to be spreadng, not only to determine the factors which control and limit their spread, but also to decide, if possible, their probable reaction if introduced into new localities. Every disease, though unimportant in its present habitat is a potential menace to the agriculture of localities not yet invaded. The increased virulence of a disease which frequently attends introduction into new regions is too well known to need exposition here. Our vast country has such varied climatic and other environmental conditions that a disease which is negligible in New England or Wisconsin may easily prove to be a scourge in Texas or California. Hence every disease of limited distribution is a subject of greater suspicion than is one which is already widespread.

Let me illustrate the value of plant disease survey work on diseases of restricted distribution by a brief summary of the Survey work conducted this fall on the disease of corn caused by *Physoderma zeae-maydis*. During the last two years this disease was found to be generally distrib-

uted through the south Atlantic states and gulf states, from North Carolina, to Mississippi, including Tennessee. Reports of its destructiveness varied from "negligible" to "the most serious corn disease." The disease was not known to occur north of the Carolinas and Tennessee, nor west of the Mississippi River, but the potential menace to the corn states of the north and west was producing serious uneasiness in view of the enormous losses known to be caused by similar diseases in the orient, and the general uncertainty regarding the nature of the disease in our own southern states. Accordingly the Plant Disease Survey this fall sent scouts into the field to study the disease in close coöperation with the Office of Cereal Investigations of the Bureau of Plant Industry and with the assistance of our collaborators and of other pathologists in the states visited. To our surprise we found the disease was present as far north as New Jersey and Minnesota and as far west as Nebraska and Oklahoma, and that it had probably been in this country long enough to have spread nearly, if not quite, to its northern and western limits where it is held in check by the controlling factors of low temperature and lack of moisture. The disease was found in nineteen states where it was not previously known to exist, including all of the great corn-raising states. Fortunately we found that the disease does not cause great damage through the north and west, its destructiveness being limited to regions of considerable moisture and of continuous high temperature, especially during the early part of the corn season. We have thus determined the distribution of the disease, cleared up the uncertainty as to its destructiveness, and obtained much valuable information as to its nature and relation to environmental conditions. The results of the survey have been summarized in the Plant Disease Bulletin and all data placed at the disposal of those investigating the disease. The discovery of the disease distributed in nineteen states where it has heretofore been overlooked by both federal and state pathologists, even though in some regions it is prevalent and causing considerable damage, conclusively proves the need of intensive survey work by trained field men in order that our plant disease problems may be clarified and definitely delimited.

I will mention but one more service the Plant Disease Survey should perform, which is to assist in educating the public in the importance of the investigation and control of plant diseases. Ignorance and indifference on the part of the grower block general adoption of control measures, and apathy of the general public influence our legislators and so restricts our funds. To dispel this indifference we must marshal our facts and they must be definite. There is at present too much vagueness about many of our statements, and hard-headed farmers and business men are not impressed. This is especially true of our information regard-

ing losses due to plant diseases. The unscientific inquirer wants estimates and figures, and does not appreciate the difficulties in the way of preparing such figures. The Plant Disease Survey has frequent requests for statements as to the losses due to some disease or to diseases in the aggregate. We have little data to give of any value, and the specialists on various diseases have little more. So far as I know very few pathological workers have in the past attempted careful estimates of loss for any disease, even for small areas. How can we expect practical men to be properly impressed with the importance of our work and to vote large sums of money for its support when in place of facts we have only vague guesses to give them and when we do not take the trouble to make careful estimates? Determination of loss is a difficult and complicated matter, but I believe we should seriously attempt it. We should develop quantitative methods, and make careful counts in restricted areas. I believe the accumulation of reasonably accurate data on losses will ensure us the attention of the public as will no other argument. There is little difficulty in obtaining large appropriations to combat human diseases or diseases of domestic animals, for the ravages of these maladies are readily seen and understood and losses are easily computed. The preparation of reliable and comprehensive estimates for even a few of the more serious plant diseases would be of immense educational value to the public and would tend to increase the support given all plant disease work.

Without dwelling further on the service to be rendered by the Plant Disease Survey, let us pass to a consideration of our plans for organization. We have two sets of problems—state or local problems and general ones. We are, therefore, developing an organization in each state under the leadership of the state pathologist, which shall handle local problems, leaving the more general matters to the central office in Washington. We must depend on the state organizations to keep in close touch with the disease situation in all parts of their respective states and to report the same to the Washington office. The logical person for state leader in this work is the state pathologist at the experiment station who is the head of the pathological machinery in his state. He is, therefore, in a position not only to collect the information desired but also to make immediate use of it in the solution of local questions. Our problems of organization are complicated by the wide variation in conditions under which the state pathologists work. Some have competent staffs of assistants, adequate funds for carrying on research and field work, and they now have a good grasp of the general disease situation in their states. In such cases we can easily arrange satisfactory plans for coöperation. Other state pathologists are handicapped by lack of both money and men, are harassed by manifold duties, and, since they are unable to under-

take field work, know but little of the distribution and prevalence of diseases in their states. They must depend largely upon correspondence for their data and to increase this is to impose additional burdens. Therefore, each state presents its own problems of organization for us, and the type of machine we develop in a given state must depend upon local conditions and must change as those conditions change. But even in the states where conditions are least favorable, some plant disease survey work can be done, and with the assistance of the Washington office, with the advice and example of other states, with the impetus of the whole movement to aid, development should be steady and rapid. I believe there are many states where Plant Disease Survey coöperation will prove of material assistance in the pathologists' struggle to improve the conditions under which they work.

The most efficient mode of collecting data on plant diseases is to send trained observers into the field, and in time we hope to have a permanent corps of experienced scouts, skilled in observing and recording disease data. But the maintenance of field men is expensive and requires larger funds than are now available if it is to be undertaken extensively. Moreover at the present time competent field men are becoming scarce, although we may hope to partially overcome this shortage by utilizing vacation periods of teachers and of station workers. We must, therefore, depend for much of our data on correspondence and on the coöperation of many competent observers, each of whom reports on his immediate locality, and on any region he may be able to visit. We shall thus accumulate a large body of data of a dependable character which can be verified and supplemented by field work so far as possible, especially in the case of important crops and diseases. Many of our collaborators have already a large corps of reporters and correspondents. These lists should be extended as much as possible, that no available source of information may be overlooked. In this phase of the work much depends on the personality of the state pathologist, on his energy and tactfulness, and on his ability to command the coöperation of his colleagues and of his fellow botanists throughout the state.

But the development of a large list of correspondents is of small value unless there are adequate facilities for caring for the data and specimens sent in, so that the accumulated information may be readily available. Unfortunately too many of our collaborators now lack these facilities, and the remedying of this situation is one of our major problems. The local conditions are too varied to permit general discussion here, but I will say that I believe each collaborator should make every effort to convince the station authorities of the fundamental importance of survey work, to the end that it shall be made a part of the regular yearly program

of work and so be given necessary financial support. This has already been done in a number of states and should be brought about in all as rapidly as possible. The assignment of only a modest sum would give survey work a start and the standing it requires to ensure adequate development in the future.

The work of the central office in Washington falls into three main categories. In the first place it aims to act as a center of organization, that all sources of information may be utilized, that the work may be systematized and coördinated, and that there may be harmony of methods and of aims. To this end it shall assist the state organizations in every way possible, strengthening and supplementing their work where necessary, and it shall strive to promote a spirit of coöperation amongst all pathologists which will result in greater accomplishment.

Secondly, the central office, while leaving the accumulation of general disease data as far as possible to the state organizations, shall study the general problems of disease distribution, of relative prevalence and seriousness, of environmental relations, of epidemics, of new diseases, and other matters of general rather than local importance.

And lastly, the central organization shall receive data from all sources, shall analyze it and reissue it in some form for immediate and general use. This last season we have answered many special requests for information on topics relating to plant diseases; we have begun the semimonthly issue of the Plant Disease Bulletin in mimeographed form, containing summaries of data on certain diseases; and we are now preparing a general summary of all data collected for 1917 which we hope to have printed as a government bulletin. The general approval accorded the first numbers of the Plant Disease Bulletin shows the need for such a publication. Improved facilities next season should enable us to materially improve the quality of the Bulletin, and to send it more widely to those interested in plant diseases. I believe a regularly printed journal devoted to plant disease survey data would be desirable and should be considered as a possibility of the future.

I have outlined some of the work the Plant Disease Survey hopes to perform and some of our plans for accomplishing it. There are many other problems ahead of us which I cannot profitably touch upon here. Although this is not a new work, it is a new method of attack. We are endeavoring to systematize and coördinate what in the past has been sporadic and fragmentary, and as we develop our plans new fields of usefulness open out before us.

This is coöperative work in which each of you can have a part, no matter what his immediate field of work or his geographical location. Each one can cover some territory, no matter how limited, about his

home. We can save and pass on the information which comes to us during our day's work. We can bring back data from a holiday's tramp afield. Vacation periods may be utilized for active survey work. Graduate students and members of classes in mycology and pathology may be led to do practical field work. The interest of the farmers and of the general public in the problems of disease control may be fostered.

Let us remember that all information on plant diseases is valuable and worth reporting. Your report may concern diseases well known, and for which control measures have already been worked out. In such cases, data on prevalence and losses will help to arouse the public and to direct control campaigns, and in the case of diseases like late blight of potato early notice of the first appearance of the disease for the season may lead to prompt measures to prevent a serious epidemic. Or your report may concern diseases not so well known and which are now being studied, in which case your information will help the investigator in solving the problems before him. And lastly, your report may concern diseases which are apparently of small importance and your information may seem to be of little immediate value, but later it may become very significant in the light of accumulated evidence or of future discoveries. I believe as botanists we have a public service to perform, especially at this time, and that it is as much our duty to report information bearing on the preservation of the nation's food supply, as it is to report any menace to property or to the public health and safety.

I see before us a new day for plant pathology, one of great development and of increased usefulness. Many things are pointing to this, and the world war is hastening its coming. The maintenance of an adequate food supply is of vital and increasing concern to the world, and the necessity of checking the enormous wastage due to plant diseases is being more and more impressed on both the producing and the consuming public. As the guardian of the health of our food crops the plant pathologist occupies a position of increasing importance and responsibility. I believe he will discharge this responsibility acceptably. We have schools and professors for teaching pathology; we have laboratories, equipment and trained investigators for research. Extension work is rapidly developing and the Plant Disease Survey is now perfecting an intelligence service which shall supplement and complete other pathological work. I can see no insuperable barrier in the path of plant pathology and those obstacles which do exist will be swept aside by the organized coöperation which I believe will mark pathological work of the future.

SEED TREATMENT CONTROL AND OVERWINTERING OF CUCUMBER ANGULAR LEAF-SPOT

W. W. GILBERT AND M. W. GARDNER

Carsner[1] has shown that the causal organism (*Bacterium lachrymans*, Smith & Bryan) of cucumber angular leaf-spot may overwinter with the seed and cause seedling infection. From laboratory and greenhouse tests he concludes that the disease is introduced into fields with the seed. The purpose of the work herein reported was to prove this theory by field tests and to test the efficacy of seed disinfection as a control measure.

Since single row field tests had proved inadequate with a disease which spreads as rapidly as this, recourse was had to large scale tests in which whole fields were compared more or less as units. Two classes of tests

TABLE 1

Madison field tests of seed treatment control of cucumber angular leaf-spot

FIELD	PREVIOUS CROP	ACREAGE	SEED TREATMENT	DISEASE FIRST APPEARED	DISEASE PREVALENT
1	Diseased cucumbers	1.3	$HgCl_2$, 1:1000, 5 minutes rinsed, 15 minutes	July 21	July 27
2	Not cucurbits	½	Untreated	July 9	July 21
3	Not cucurbits	¼	0.5 per cent $CuSO_4$, 10 minutes, rinsed ½ hour	July 29	August 25
		¼	1 per cent $CuSO_4$, 5 minutes, rinsed ½ hour	August 1	August 25
4	Not cucurbits	¼	2 per cent Formalin, 10 minutes, rinsed 5 minutes	August 25	September 8
		¼	4 per cent Formalin, 5 minutes, rinsed 5 minutes	July 24	August 25
5	Not cucurbits	¼	Hot water, 52°C., 10 minutes	July 21	September 8
		¼	1915 seed (stored 20 months)	August 1	September 8

[1] Carsner, Eubanks. Angular leaf-spot of cucumber: dissemination, over wintering, and control. Mss. in press. Jour. Agr. Res., U. S. Dept. Agr.

were carried out in 1917, one on a few fields under continuous observation at Madison, Wisconsin, the other a coöperative trial on a large number of fields in three states. Unless otherwise stated, seed produced the preceding year was used.

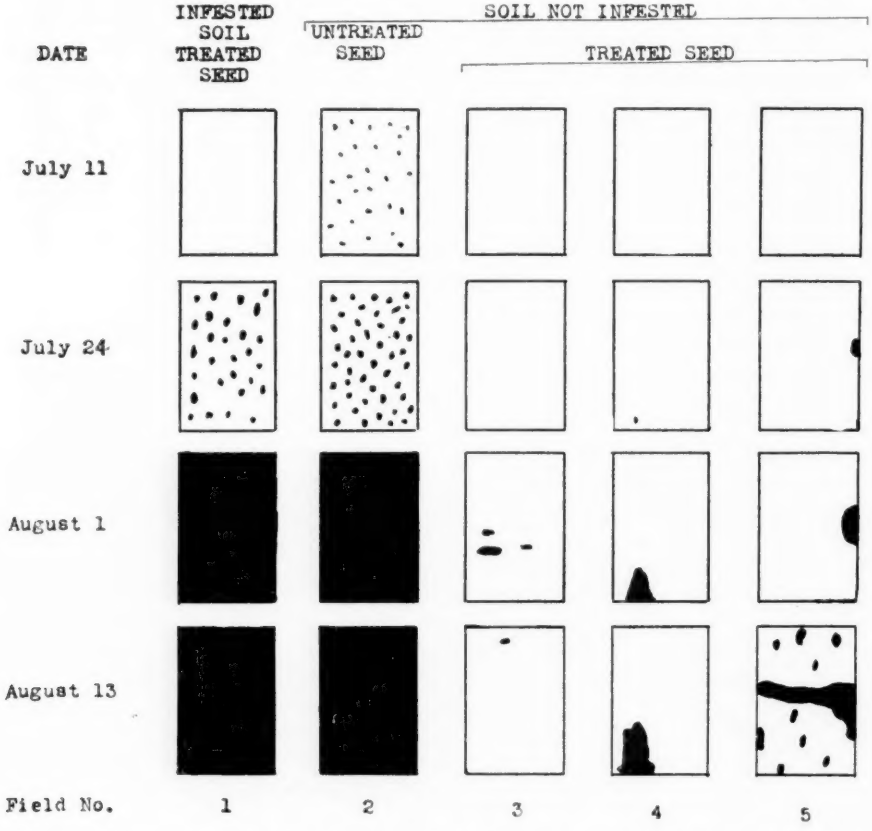


DIAGRAM ILLUSTRATING MODE OF INCEPTION AND PROGRESS OF ANGULAR LEAF-SPOT IN THE FIVE MADISON FIELDS.

Blackened areas represent disease. Field numbers correspond with those on table 1, in which previous cropping and seed treatment are shown.

In table I is shown the plan of the tests conducted on five fields at Madison and the results as determined by frequent inspection. These fields were 100 yards to $\frac{1}{4}$ mile distant from each other. It will be noted that controls on the tests of treated seed in clean soil are afforded by the use of treated seed in a field which bore a diseased crop the previous year and by the use of untreated seed in a field not previously in cucurbits.

Considering first the four fields on clean soil, evidence that the disease was introduced with the seed is furnished by the fact that in field 2, planted with untreated seed, the disease appeared twelve to twenty days earlier and became prevalent a month sooner than in fields 3, 4, and 5 planted with treated seed.

Considering next the four fields in which treated seed was planted, the fact that the disease became prevalent in field 1 a month earlier than in fields 3, 4, and 5 not previously in cucurbits indicates overwintering in the soil. This view is further strengthened by the very early appearance and rapid spread of infection in a sixth field, not included above, which was diseased the previous year.

Furthermore, angular leaf-spot became destructive in both of the control fields by the first of August while, in the other three fields, the disease never reached that stage.

The mode of inception and progress of the disease in these five fields is graphically represented in the following diagram.

It is apparent that, in both check fields, the disease broke out in numerous centers and rapidly became prevalent while, in the three fields wherein treated seed was planted in clean soil, the belated appearance of the disease in a few isolated points and its slow spread from the latter indicate that a marked control was obtained. The important point to note is the striking contrast in time and mode of origin and rate of progress of the disease between the check fields and the other fields. Since the work in all of these fields was done by the same crew of workmen, it is entirely possible that the latter may have carried the infection to fields 3, 4, and 5. These results indicate that epiphytotics of angular leaf-spot may originate from either infested seed or infested soil.

Since surface sterilization of the seed so effectively checked the disease, it seems safe to assume that the bacteria are on the exterior of the seed. It is significant that the old seed twenty months in storage also appeared to be disease-free. Since much of the cucumber seed used is more than one year old, further tests should be made to determine whether such seed still carries infection. All of the treatments given in table 1 seemed to be equally effective and injury resulted only from the formalin.

To test the efficacy of seed treatment on a large scale, all of the seed distributed by a pickling company to its growers from one salting station in each of the states of Michigan, Indiana, and Wisconsin, was previously treated in mercuric chloride 1: 1000 for five minutes and rinsed fifteen minutes. Similar seed, untreated, was used in contiguous districts as a check. In August and September a number of fields in each of these six territories were inspected for disease occurrence. In Michigan inconclusive results were obtained because very little disease occurred even in

the check fields. In Indiana and Wisconsin, seed from another source was used and the results are presented in table 2. Here it will be noted that allowance has been made for the possibility of infested soil by eliminating all cases in which the 1916 cucumber crop was on the same or a nearby field as determined by inquiry from the owners.

In the Indiana fields, a net gain of disease prevention in 35.8 per cent of the fields is attributable to seed treatment. On a comparative basis, this would mean a prevention of 71.6 per cent of the outbreaks that would otherwise have been expected. The results in Wisconsin are less striking. Similarly, eliminating from the totals the cases possibly due to soil infestation, the incidence of the disease is reduced from 49.3 per cent to 26.6

TABLE 2

Coöperative field tests of seed treatment control of angular leaf-spot of cucumber

STATE	EFFECT OF SEED TREATMENT						OVER-WINTERING
	Seed	No. of fields	Diseased.		Not due to 1916 crop		Per cent of cases of disease possibly due to 1916 crop
			No.	Per cent	No.	Per cent	
Indiana	Untreated	30	25	83.3	15	50	40
	Treated	42	8	19.1	6	14.2	25
	Net gain due to seed treatment					35.8	
Wisconsin	Untreated	43	29	67.4	21	48.8	27.5
	Treated	33	20	60.6	14	42.4	30
	Net gain due to seed treatment					6.4	
Totals	Untreated	73	54	74	36	49.3	33.3
	Treated	75	28	37.3	20	26.6	28.5
	Net gain due to seed treatment					22.7	

per cent by seed disinfection. This indicates a net gain of 22.7 per cent in freedom from disease or a prevention of 46 per cent of the cases that would otherwise have been expected.

As to the importance of soil infestation, it is seen that, where treated seed was used, 28.5 per cent of the cases of angular leaf-spot were possibly attributable to a previous crop. Where untreated seed was used, one-third of the cases are in this category. Further analysis of the data relative to the importance of crop rotation is presented in table 3.

Among the fields planted with treated seed, it is seen that the disease occurred in two out of the seven in which rotation was not practiced and in six out of the ten located adjacent to or near the 1916 cucumber fields. Of the twenty-one fields planted with untreated seed and located on or

TABLE 3

Relation of previous cucumber crop to the occurrence of angular leaf spot

STATE	SEED	NO. OF FIELDS	1916 CROP ON SAME SOIL		1916 CROP ADJACENT OR NEARBY	
			No. of fields	No. of fields diseased	No. of fields	No. of fields diseased
Indiana	Untreated	30	10	8	3	2
	Treated	42	4	0	4	2
Wisconsin	Untreated	43	4	4	4	4
	Treated	33	3	2	6	4
Totals	Untreated	73	14	12 (85.7%)	7	6 (85.7%)
	Treated	75	7	2 (28.5%)	10	6 (60%)

near the 1916 site, eighteen or 85.7 per cent showed the disease. There seems to be danger in planting within several hundred feet of fields used for cucumbers the previous year, particularly if the drainage is toward the new fields.

To summarize, it may be said that epiphytotics of angular leaf-spot may originate from contaminated seed or infested soil and that seed disinfection reduces the incidence of the disease nearly one-half. The use of treated or disease-free seed in fields well removed from previous cucumber patches is recommended as a control measure.

For seed treatment, immersion in a 1–1000 mercuric chloride solution for five minutes followed by fifteen minutes washing has proved most satisfactory from the standpoint of safety and effectiveness and is being used on a commercial scale this season.

BROWN BLOTCH OF THE KIEFFER PEAR

GEORGE W. MARTIN

The most generally prevalent fruit spot of the Kieffer pear in southern New Jersey is known locally as "brown blotch" and occurs most commonly as reddish brown spots or blotches. While the Kieffer is the pear most seriously attacked, the disease is also frequently found on Le Conte, and less commonly on Lawrence and other varieties. The spots, when small and scattered, are usually circular, but without well-defined borders separating them from the surrounding epidermis. As the season progresses a number of the spots unite, forming large, irregular patches or blotches, frequently covering one side of the fruit, and sometimes the entire pear (fig. 9). These blotches resemble very closely the natural russet coat characteristic of certain varieties of pears, and it is this fact which has prevented a clear recognition of this condition as a disease of parasitic origin. Sometimes the disease takes the form of scabby or scalded areas on the fruit. In such cases the epidermis becomes checked and flaky, closely resembling that injured by frost, sprays and mechanical abrasions. This resemblance is so marked that in this instance, again, it is not surprising that the condition has not been recognized as due to infection. This latter phase, while less common, seems usually to be present to some extent in connection with the more ordinary form of the disease.

The material studied was grown in New Jersey, but Kieffer pears attacked by the typical form of the disease have been purchased in the markets in Chicago, Illinois, and in Amherst, Massachusetts, grown in the vicinity of these two places. The disease is probably widespread.

The trouble is of some economic importance. When the fruit is marketed, the unattractive appearance of the blotched pears makes it necessary to sell them at a considerably lower price than that received for clean pears, in spite of the fact that the pulp is entirely undamaged. In addition to this, experience has shown that while blotched pears seem to keep about as well as clean pears in cold storage, they shrivel up and dry out more rapidly when taken out of storage than healthy pears. This fact has been confirmed by laboratory experiments. As a large number of Kieffer pears are held in cold storage for some months after picking, this is an important consideration.

Literature on the subject is scanty. There are a number of indefinite references in the proceedings of the New Jersey State Horticultural Society during the past fifteen years, and a definite reference by Warren and Voorhees (1) in 1906. These authors attribute "cloudiness" or rusty coat to three causes: first, to frost; second, to strong spray mixture; third, to fungi. They are "of the opinion that the greater part of the "cloudiness" is due to after effects of fungous diseases, probably . . . . other than scab. Certainly some of it is due to fungous diseases. The almost universal experience that it is worst in shaded parts of a tree and in trees with dense tops strengthens this view."

In 1905 Farneti (2) described from Italy what he called the chaffy spot of the pear, attributing it to a new species of Macrosporium which he named *M. sydowianum*. His article makes no mention of inoculation experiments nor of isolating the organism, but merely describes it as constantly associated with the diseased condition of the fruit. His description of the diseased Italian pears, however, agrees perfectly with that of the diseased New Jersey pears, and his microscopic observations agree also except in one particular, to be noted. For this reason the disease was tentatively attributed to Farneti's organism in a preliminary report made at the Columbus meeting of the American Association for the Advancement of Science in 1915 (3) and in a circular on pear diseases issued shortly thereafter (4). The writer is now of the opinion that the New Jersey disease is the same as the disease described by Farneti, but that the presence of Macrosporium spores is purely accidental, and that these have no causal relation to the disease.

The disease is unquestionably of fungous origin. Thin sections of the epidermis of a healthy pear, cut parallel with the surface, when examined under the microscope are of a translucent green or yellow color and regular in texture. Sections from a portion of the epidermis diseased with the brown blotch, when examined in the same way appear of a dense brown color and of uneven texture, and the surface is dotted with very small sclerotia connected by an interlacing network of mycelium. The sclerotia vary greatly in size and shape, but are often from 30 to 60 μ long and about half as wide. The microscopic appearance is very similar to that of the common sooty blotch fungus (*Leptothyrium pomi* (Mont. & Fr.) Sacc.). The hyphae and the sclerotial cells of the pear fungus are smaller, however, than the similar structures of the sooty blotch organism, and the mycelial strands connecting the sclerotia are in general straighter. A more important differences is that Leptothyrium is described as entirely superficial, or as merely roughening the cuticle of the host, while in the case of the pear fungus the surface of the host is greatly roughened, the sclerotia burying themselves in the thick layer of cutin and causing exces-

sive suberization of the underlying cells, as a result of which the skin becomes rough, brown and dry.

In studying fresh freehand sections of the diseased areas, the relations of the fungus to its host were brought out more sharply by staining for fifteen minutes in an aqueous solution of Ruthenium red, diluted until it was a faint pink. Satisfactory permanent preparations were made by killing in Gilson's fluid and staining with Durand's combination of eosin and haematoxylin (5).

The effect of the fungus on the fruit may be briefly summarized. In healthy pears the outer layer of epidermal cells is strongly cutinized and underneath this layer are several suberized layers. Within is the parenchymatous pulp enclosing numerous groups of stone cells. The fungus, growing on the surface, attacks the cutin and then the underlying cells (figs. 1, 2, 4 and 5), causing the formation of new suberized layers. In severe attacks the old cork layers flake off, leaving the roughened areas on the surface of the fruit. The lignin of the stone cells is unaltered and frequently the suberization of the subepidermal layers results in the appearance of isolated groups of stone cells imbedded between two series of cork layers. The more rapid drying out and shrivelling of diseased fruit as compared with healthy would seem to indicate that the increase in cork layers does not offset the injury to the cutin. The fungus itself may be accountable for the withdrawal of an appreciable quantity of water from the fruit. The disease seems also to be associated with a checking of growth, resulting in deformity when the attack is early and predominantly on one side.

Fig. 9. Brown Blotch of Kieffer Pear.

According to Farneti the Italian organism fruits freely, and he describes typical Macrosporium spores, 28 x 12 μ in size, as arising in clusters of three or four in the roughened area. A Macrosporium was found very sparingly associated with the disease in the New Jersey material and agreed closely with Farneti's description except that the spores averaged 24 x 9 μ. Attempts to isolate this organism were unsuccessful, but an Alternaria having spores of similar appearance and size was frequently

secured in pure culture. Inoculation experiments were made by spraying the surface of half grown Kieffer pears with a suspension of the spores of this organism in sterile water and bagging them. The results were entirely negative. Parings of diseased skin from mature pears were kept in a cork stoppered bottle over winter and pears were similarly sprayed with a suspension made from this material and then bagged, but no infection was secured.

It is suggested that the fungus causing the disease is closely related to the organism of sooty blotch, *Leptothyrium pomi*, or is a variety of that organism. It is distinguished from the typical form by its smaller size, by the straighter connecting strands and by the fact that it is not superficial but burrows into the cutin and causes extensive suberization and hypertrophy of the subcuticular layers of the host. The examination of fresh material and of paraffin sections of sclerotia collected at all seasons of the year has given no indication of a fruiting structure, and in this respect the material agrees very closely with what has been the general experience with *L. pomi*.

The disease is readily controlled by two rather late sprayings in addition to the regular spring treatments; about the first of July and the first of August being effective in New Jersey. Weak Bordeaux mixture made according to the 3–4–50 formula is somewhat more effective than dilute lime-sulphur solution (4).

It was the intention of the writer to make more extensive studies on this subject but the call to military service has made further study impossible at this time.

The writer begs to acknowledge his indebtedness to Dr. M. T. Cook, under whose direction this work was undertaken, for many helpful suggestions

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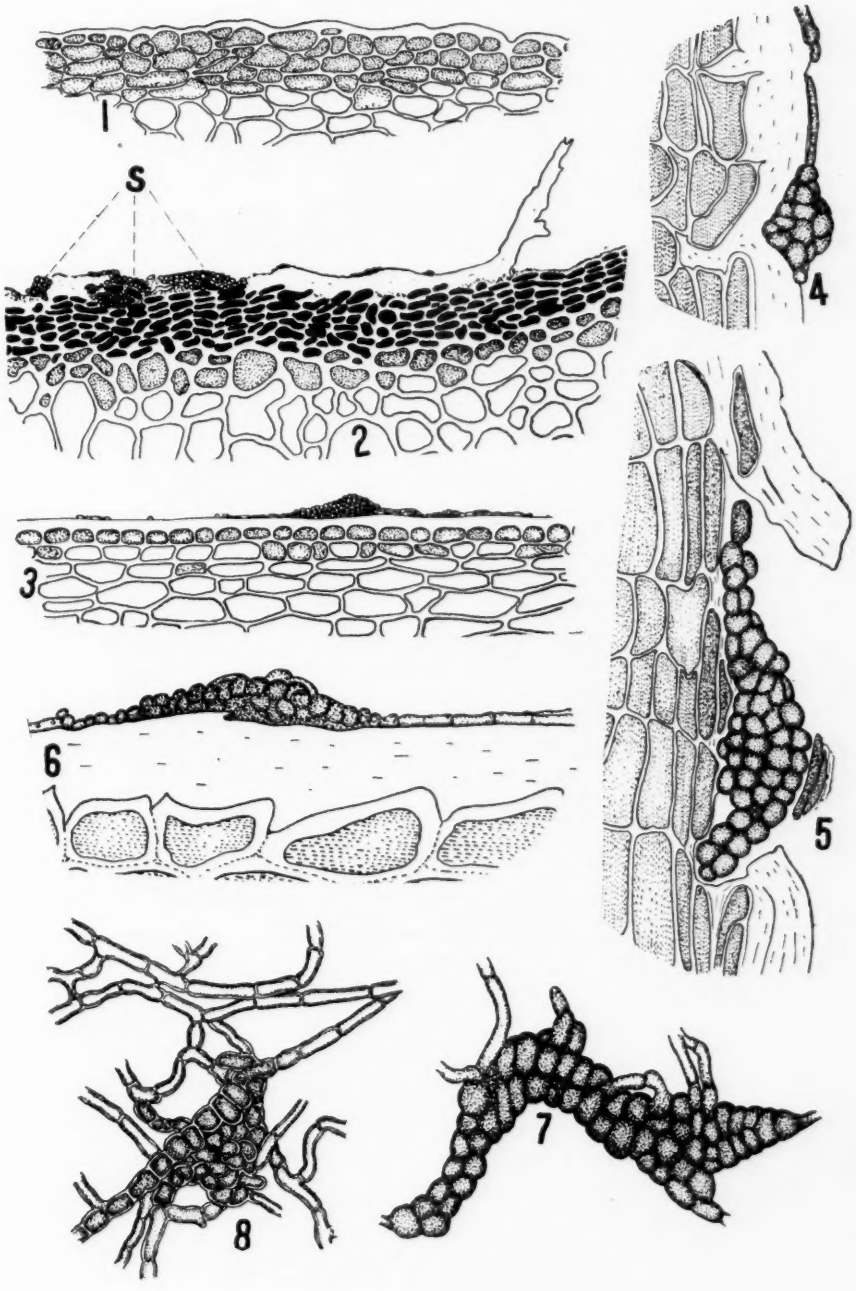
Fig. 1. Section through outer layers of a healthy pear, x 160. Fig. 2. Section through similar layers of a badly diseased pear, showing flaking off of the cutin and excessive suberization of the underlying layers, × 160. Sclerotia indicated at S. Fig. 3. Sclerotia and mycelium of *Leptothyrium pomi* on surface of apple, showing unchanged underlying tissues, × 160. Fig. 4. Beginning of invasion of cutin of Kieffer pear by brown blotch sclerotium, × 740. Fig. 5. Later stage of same, showing destruction of cutin and invasion of cork cells, × 740. Fig. 6. Sclerotium of *Leptothyrium pomi* on apple, × 790. Fig. 7. Surface view of sclerotium of brown blotch from Kieffer pear, × 740. Fig. 8. Surface view of small sclerotium and mycelium of brown blotch on small wild pear, × 740.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COPPER SULPHATE AS A DISINFECTANT FOR POTATOES

G. R. Bisby and A. G. Tolaas

Some interest was manifested at the Pittsburgh meetings with regard to the possibility of using copper sulphate solution as a disinfectant for potatoes. The writers therefore submit the results obtained at University Farm during the past three years with different disinfectants.

Since the 1914 results were inconclusive they are not included. These first results indicated that strong copper sulphate solutions might injure the seed, especially if cut; weaker solutions were not effective.

Summary of results with seed treatments for 1915, 1916, and 1917

SOLUTION	STRENGTH	TIME	AVERAGE PERCENTAGE OF PROGENY WITH BLACK SCURF
		hours	
Copper sulphate	3 pounds to 50 gallons water	2	42.1
Corrosive sublimate	4 ounces to 30 gallons water	2	48.0
Formaldehyde solution	1 pint to 30 gallons water	2	54.1
Lime sulphur	1:40	2	62.3
Lime sulphur	1:30	2	73.5
Check, no treatment			74.9

Seed with black scurf was used. Percentages of progeny affected were obtained by washing the potatoes, examining while wet, and counting the number of tubers showing sclerotia of *Rhizoctonia*.

The results are not conclusive for the following reasons: (1) The soil at University Farm is not well adapted to potatoes, being of an acid reaction, and yielding generally an unsatisfactory crop. Potatoes "degenerate" if grown a few successive years on this soil. (2) The differences in percentage are not large, and the chances for error probably more than compensate some of the differences; this is to be noted particularly in the fact that lime sulphur 1:30 did not give as good results as lime sulphur 1:40, for no obvious reason.

The results, however, are fairly consistent, and it may be worthy of note that the best average yield was also obtained from seed treated with copper sulphate. It is hoped that copper sulphate may exert some

"residual" effect in the soil to lessen somewhat soil infection. The comparative cheapness of this treatment recommends it somewhat. The writers plan to carry out some coöperative experiments with growers in various parts of the state, in an endeavor to determine to what extent it is really efficacious.

The acid soil at University Farm makes scab treatments unsatisfactory. The indications are, however, that copper sulphate is as effective as any treatment against common scab. The possibility of using a shorter time of treatment has not been tried out experimentally.

UNIVERSITY OF MINNESOTA.

APPENDIX

WASHINGTON CONFERENCE

MINUTES OF THE WAR EMERGENCY CONFERENCE OF PLANT PATHOLOGISTS OF THE CENTRAL EAST

A meeting was held at Washington, D. C., February 12, 1918, in response to a call by F. D. Kern, Commissioner for the Central East, to consider plans for war emergency work in this district.

The representatives for the states were as follows: Pennsylvania, F. D. Kern and C. R. Orton; New Jersey, Mel. T. Cook; Delaware, T. F. Manns; Maryland, J. B. S. Norton; Virginia, F. D. Fromme; West Virginia, N. J. Giddings. The following members of the War Emergency Board were in attendance: H. H. Whetzel, G. R. Lyman, H. P. Barss and E. C. Stakman, together with a number of plant pathologists from the Bureau of Plant Industry.

The keynotes of the meeting were concentration and coöperation; concentration on war emergency problems of vital importance in food production, and coöperation in research and extension on diseases common to the Central East. Plans for coöperative work between the Bureau of Plant Industry and the States were presented by the offices of Cotton, Truck and Forage Crop Diseases, Cereal Diseases and Fruit Diseases. The state pathologists discussed the needs of their states for such work and voiced a unanimous wish for full and hearty inter-State and State and Federal coördination of effort.

In pursuance of the concentration plan the diseases of the following crop plants were selected for a united assault: potatoes, sweet potatoes, tomatoes, cereals, and fruits. Leaders for specific diseases were chosen to correlate and direct the work. New and unpublished methods were given out and the discussions proved a mine of practical and immediate information. The coöperators adjourned with firm convictions of the desirability and practicability of inter-State and National unity of action.

The sentiment and action on specific diseases are indicated in the following:

Potato diseases

1. Seed potato improvement. A plan for the improvement of the seed potato situation through the location of superior seed stock by field inspection was discussed by W. A. Orton and H. A. Edson. It was shown that this work would uncover large quantities of suitable seed not now available and would also stimulate growers to a realization of the value and necessity of potato disease control. The plan involves coöperative work between federal and existing state agencies.

2. Late blight. Since this disease is of chief importance in the North East section it was the sense of the meeting that the pathologists of the Central East should coördinate their work with that of the North East. C. R. Orton and N. J. Giddings were elected leaders for the Central East.

Sweet potatoes

A general extension campaign for the prevention of field and storage losses is to be conducted under the leadership of L. L. Harter. The plan, which divides the sweet potato states into four sections with a pathological advisor in each, was explained by the leader in detail. No coöperative research on sweet potato diseases was planned.

Tomato diseases

There was an unusual amount of interest in tomato diseases, due to the present scarcity and high prices and low production last year.

1. Fusarium wilt. F. J. Pritchard, who was made leader in the work to be undertaken on this disease, stated that seed of a wilt resistant selection of Stone was now being disseminated to the states for distribution to the farmers, and that experimental work on other varieties is under way.

2. Septoria leaf-spot. This was considered by some to be the chief outstanding problem of the section, and all state men present expressed their willingness to coöperate in research and demonstration on this disease. Emergency work was placed under the leadership of F. J. Pritchard who described a spray formula which has controlled the disease in his experiments and which he is prepared to recommend.

3. Early blight and late blight. These diseases are not general over the Central East, but are destructive locally. Leadership on early blight (Alternaria) was assigned to C. R. Orton, and that on Phytophthora late blight to N. J. Giddings.

Cereal diseases

Coöperative extension work on seed treatment for the preventable diseases of cereals is being carried on under the direction of H. B. Humphrey. The work is to be continued and expanded next year. The need of men to carry on this work was emphasized.

A coöperative research project to determine the effect of different seed treatments on viability of grain was presented by E. C. Stakman. Four of the state men indicated their intention of coöperating in making the tests.

Fruit diseases

The importance of fruits as substitute foods was pointed out. It was thought best for the coming year to devote efforts to putting known control measures into practice. The importance of supplying information to growers and storage men on methods of handling which would reduce the present enormous losses subsequent to harvest was especially stressed. Leaders on fruit diseases were elected as follows: Apples, Charles Brooks and N. J. Giddings; peaches, M. B. Waite and T. F. Manns; strawberries and grapes, C. L. Shear.

Man power

The shortage of plant pathologists was emphasized by a number of speakers. The committee on man power of the War Emergency Board, consisting of F. D. Kern, C. R. Orton and V. B. Stewart, announced that the man power census is making good headway. Some nine hundred questionnaires have been sent out with three hundred returned. The men are classified according to experience, training, and availability, and a list will be supplied in the near future.

(Signed) F. D FROMME,
Secretary.

BOSTON CONFERENCE

MINUTES OF THE WAR EMERGENCY CONFERENCE OF PLANT PATHOLOGISTS OF THE NORTHEAST

A meeting of plant pathologists of the Northeast District, held at Young's Hotel, Boston, Massachusetts, March 1 and 2, at the call of Commissioner H. H. Whetzel of the War Emergency Board, was attended by the following:

Representing Maine, W. J. Morse; New Hampshire, O. Butler; Vermont, B. F. Lutman; Massachusetts, A. Vincent Osmun, G. H. Chapman, P. J. Anderson, W. S. Krout, W. L. Doran; Rhode Island, Miss Harriet L. Merrow; Connecticut, E. M. Stoddard; New York, H. H. Whetzel, M. F. Barrus, M. C. Burritt; Pennsylvania, C. R. Orton; Harvard University, W. G. Farlow, Roland Thaxter, A. B. Seymour; Dartmouth College, A. H. Chivers; Brown University, H. H. York; Carnegie Institution, Cold Spring Harbor, A. F. Blakeslee; Brooklyn Botanical Garden, E. W. Olive; Syracuse University, L. H. Pennington; Bureau of Plant Industry, G. R. Lyman (Plant Disease Survey), W. W. Gilbert and George K. K. Link (Office of Cotton and Truck Crop Investigations), Neil E. Stevens (Office of Fruit Disease Investigations).

The meeting was called for the discussion of phytopathological problems and plans for war emergency work. Commissioner Whetzel, presiding, outlined the aims of the War Board and emphasized the need of coöperation and coördination as a war emergency measure. He reported almost universal approval of the plans of the Board on the part of pathologists and administrative officials. In the discussion which followed it was brought out that many important pathological problems are common to a large part of the Northeast and the importance of full cooperation between the states and with the United States Department of Agriculture was recognized by all.

It was the consensus of opinion that the summer's campaign for the suppression of plant diseases should be concentrated on those diseases of food crops which are best understood and for which control measures have been worked out; further, that during the present emergency research should be devoted, as far as possible, to projects dealing with diseases of important food crops.

In order to facilitate discussion, a committee was appointed to arrange a crop order for the meeting. In pursuance of the report of this committee the principal diseases of the following crops formed the basis of discussion and action by the assembly: potato, apple, cereals, beans, onion, other truck crops, peach, pear, strawberries, other small fruits, tobacco.

Leaders were selected to collect and formulate information on the diseases of specific crops and those specially interested in each case were designated a committee to act in coöperation with the leader. The sense of the meeting on the different diseases follows:

Potato diseases. Dr. W. J. Morse of the Maine Station was elected leader for potato diseases. A committee of those interested was instructed to formulate and report on methods of treating "seed" potatoes for scab and Rhizoctonia, and a standard procedure for potato spraying. The report follows:

Seed potato treatment

"Diseased seed tubers should be sorted out as far as possible.

"When there is visible evidence of scab or Rhizoctonia or where blackleg is known to have occurred in the field where the stock was grown the seed should be treated. However, the farmer should always be informed that where the land is infested seed tuber treatment will not be entirely effective.

"We recommend both corrosive sublimate and formaldehyde for seed treatment, but, all things considered, would give preference to the first named."

Potato spraying

"For use in this section we do not recommend a bordeaux mixture weaker than 4–4–50. In regions where rainfall is excessive a 5–5–50 may be desirable.

"Begin to spray when the plants are six to eight inches high. Spray often enough to keep new growth covered. Spray *thoroughly* from the first. When the plants are large use at least 100–150 gallons per acre. Pressure should be sufficient to produce a fine driving mist."

The report of the committee was unanimously adopted.

The discussion pointed to mosaic, leaf roll, net-necrosis and Rhizoctonia as offering the more important problems for research.

It was agreed that extension work on potato diseases should be concentrated on "seed" selection, "seed" treatment and better spraying.

There was also general agreement that the best results from spraying are to be obtained by the use of bordeaux mixture and that commercial copper fungicides are generally less adhesive, less effective and more expensive than home-made bordeaux mixture.

Apple diseases. The discussion centered largely on methods, materials and schedules for spraying. Commercial lime-sulfur was reported in general use in the states represented. The feeling prevailed that dusting with finely ground sulfur should be more widely tested.

Large losses due to scald in storage were reported and the importance of wider application of known means of control was urged by Dr. Neil E. Stevens, who also emphasized the great need of research in connection with losses in transit of other perishable fruits.

Cereal diseases. Practically nothing has ever been done in the Northeast on cereal disease problems. But while production of cereals in this district is small in comparison with that of the Northwest, it is felt that the control of smuts and rusts presents problems of sufficient moment to call for investigation.

Methods of smut control, especially seed treatment for smut of oats, should receive special attention in extension work this year. In this connection Dr. Barrus explained oat seed treatment by the so-called "dry" formaldehyde method. This method is to be brought to the attention of farm bureau managers.

A special drive on a disease survey of cereals is to be made and Dr. B. F. Lutman of the Vermont Station was elected leader.

Bean diseases. Discussion indicated that the greatest losses to the bean crop in the Northeast are due to anthracnose, bacterial blight, root-rots and mosaic. Much interest was evidenced in Dr. Barrus's work on beans resistant to anthracnose and the selection and growing of clean seed. It was pointed out that while anthracnose may be controlled by spraying, if applications are sufficiently frequent, growers will not make a practice of it because of the expense and that, therefore, the disease must be combatted through resistant varieties or by the planting of clean seed.

The United States Department of Agriculture will conduct considerable work in 1918 on the improvement of seed beans. Inspection of fields will be made during the summer and some form of certification will be made use of. There will be field stations for trying out various methods of obtaining good seed. Seed committees will be appointed in the counties and tests will be made of the value of western and southern grown seed for use in the East.

Dr. M. F. Barrus of the Cornell Station was elected leader for bean disease work.

Onion diseases. The greatest losses to the onion crop of the Northeast are due to neck-rot in storage and Botrytis, Macrosporium and Peronospora diseases in the field. The first three of these present control problems of considerable importance. Dr. P. J. Anderson of the Massachusetts Station was appointed leader for onion disease work.

Celery and lettuce diseases. The discussion indicated that the celery diseases most in need of investigation are late blight, crown-rot and heart-rot. Drop and Rhizoctonia rot of lettuce are the cause of much loss, especially under glass.

Cabbage and cauliflower diseases. Some interesting points bearing on control of club-root were brought out in the discussion. Work on this disease is under way in Vermont, Massachusetts and Pennsylvania.

Pathological problems connected with the growing of tobacco were briefly discussed by Dr. G. H. Chapman.

Losses in transit and storage of perishable food products were discussed at length by Drs. Neil E. Stevens and George K. K. Link. Dr. Link explained the work of the Bureau of Markets in connection with inspection and certification of crop shipments. The system provides for sending reports of observations of plant diseases in the markets to the pathologist in the state where the shipment originated. Dr. Stevens stated that the Office of Fruit Disease Investigations will concentrate in 1918 on getting fruit to market in good condition. He presented some startling figures on losses of fruit in transit and urged that emergency research on methods of preventing such losses be undertaken, especially in Massachusetts and New York.

The Plant Disease Survey. Dr. G. R. Lyman outlined plans for enlarging and improving the usefulness of the survey work. It was pointed out that the Survey is not an end in itself but that it should form the foundation for future work in plant pathology and in working out geographic problems. The work is to be tied up as closely as possible with disease control campaigns by the states and by the United States Department of Agriculture. In connection with the Survey, estimates on crop losses in 1917 have been gathered and tabulated for the use of pathologists and the education of the public. This is the first systematic attempt of consequence to collect nation-wide data on losses from plant diseases and will form the basis for estimating losses in future years. Every pathologist and administrative officer in a position to do so should give his hearty support to this important project.

Man power. Dr. C. R. Orton reported on the War Board's man-power census, stating that all pathologists who have reported to the Board have been classified. A fair percentage of these are available for emergency work. The early closing of many colleges will release others for five or six months of the year. Unquestionably there will be a shortage of men qualified to carry on pathological work and an effort will be made to have such men who are of draft age and in Class I detailed for special work in pathology. Selected lists of ten to thirty men adapted to particular types of work will be sent to anyone in need of assistance, but the Board will not undertake to send out complete lists.

Professor Whetzel stated that the attitude of the Board toward drafted men will be to endeavor to obtain their detail to special work provided the man-power situation becomes acute; but no effort will be made to support a blanket scheme for obtaining exemption for all pathologists of draft age.

It was unanimously voted to hold another meeting in November, 1918.

A. VINCENT OSMUN,
Secretary.

PHYTOPATHOLOGICAL NOTES

Effect of crown gall on apple nursery stock. Observations in Wisconsin nurseries during the past season, made in connection with official nursery inspection work, have led to the conclusion that the presence of crown gall or "hairy root" on apple nursery stock causes a reduction in value of from 17 to 18 per cent. The details are included in a paper in the Journal of Economic Entomology, Volume XI, pages 133–135, February, 1918. The method used was a comparison of the trees of first, second and third grades and culls in the infected stock with the same grades in non-infected stock. 1,012 trees were examined and it was found that whereas 65.1 per cent of the non-infected trees could be classed and sold as number ones, only 37.7 per cent of the trees bearing galls and evidences of hairy root were sufficiently large and strong for this purpose. On the other hand, an increased proportion of "number two's" among the infected trees caused the total difference in value to be less than the first comparison would indicate. The grading into sizes was done by the nurserymen in each case and the decision as to infection was made by the author.

S. B. Fracker

Tilletia on wheat in North Dakota. As Potter and Coons have called attention, in the March number of Phytopathology, to some erroneous labeling of Tilletia specimens on wheat in Exsiccati it might be well to add that Brenckle's *Fungi Dakotenses* No. 132, labeled *Tilletia tritici* (Bjerk) Wint. is really *T. laevis* Kuehn, showing that both species were present in North Dakota, 132a being as labelled.

J. J. Davis

Agricultural Index. The need of a good Index to agricultural literature was discussed by the agricultural section of the American Library Association in June, 1915, and a prompt decision was reached as to the great necessity for its publication. The business management was placed in the hands of The H. W. Wilson Company of New York.

Fifty-three popular and scientific farm journals, including Phytopathology, were selected for 1916, the first year of publication, and five issues were planned, each one to be a full cumulation from original date of publication for the year. Current numbers are in paper covers and

the annual, bound in library buckram, contains all the material for the year under one alphabet.

This year the Agricultural Index will be issued ten times and cumulated quarterly. Articles will be indexed from seventy-eight of the leading agricultural publications in the United States and ten foreign countries. In addition, there will be references to material issued occasionally from numerous unrelated sources.

The effect of disinfection on the germination of cereal seed. In connection with the recently developed informal coöperative investigation of the effects of seed treatment on germination, in which the pathologists of nearly twenty states have participated and which it is hoped to develop on an even larger scale for the winter wheat crop, some discussion has arisen over the method of counting out seeds for the testing of germination after treatment.

The testing of seed for use on the farm is performed primarily for the purpose of finding out what proportion of the seed to be used will contribute to the stand it is desired to obtain, so that, unless the seed proves to be so poor as to make it advisable to discard it, the rate of seeding may be suited to the proportion of viable seed rather than to the bulk of the seed as a whole.

In making laboratory tests of the effects of methods of disinfection on seed grain no such object is involved. The purpose of such tests is not to discover what proportion of the whole seed lot is viable after treatment, but to find what proportion of the viable seed contained in the original sample has been killed by the treatment given. It would therefore contribute to the accuracy of the test if all of the seed which is not viable could be eliminated beforehand, for the dead seed present will be a source of error in two ways; first, by reducing the number of viable seeds actually tested, and second, by introducing an element of chance into the results which will be in direct proportion to the percentage of dead seeds present. Thus if 10 per cent of a lot of wheat were not viable (a proportion not at all uncommon), the average sample treated and selected for test would contain only ninety seeds, instead of a hundred, which would actually have any bearing on the object of the test. This would not be a very serious matter if a really average sample could always be selected but, following the usual directions for selecting seeds for germination test, "good and bad, just as they come," a considerable error on either side of the correct proportion of viable seed may be introduced, which in any given case might easily upset the accuracy of conclusions as to the effect of the treatment given. It will therefore be clear that a poor lot of seed can not be used for such tests if reliable results are to be

obtained, unless the number of seeds tested is very materially increased over that needed for a satisfactory test with good seed. In the case of reduction in germination on account of mechanical injury, as when the grain is weevil-eaten or has been badly cracked in thrashing, most of the seed which will not grow can be discarded when counting out the samples for germination test. This should be done; and it can be done to advantage even in some cases where the injury is not mechanical.

In connection with the above, it seems desirable to call attention to the relation of the present methods of seed testing to a possible extension of the practice of treating seed grain on a commercial scale. Seed laws, as now framed, have made it generally imperative that seed be sold on the basis of the percentage of germination as shown by a standard test. If, in accord with the resolutions adopted by the War Emergency Board of American Plant Pathologists at their meeting in Washington on February 9, 10, and 11, a policy of compulsory treatment of seed grain is to be adopted, the various seedsmen will be operating on the same basis because all must handle treated seed; but if an effort is to be made to extend the practice of seed treatment on any other basis it will meet with no little discouragement on account of the fact that treatment of the seed is very likely to reduce the germination more or less, and no one with seed to sell is going to take this risk when the laws are so shaped that the presence or absence of disease gets no consideration as against such reduced germination. The writer would like to suggest, therefore, that one of the first steps in legislation along this line could well take the form of a revision of the seed laws so that diseased conditions which are not reflected in the percentage of germination will receive some consideration. This will unquestionably involve, sooner or later, the inspection of standing grain to be used for seed, in much the same way as is already done for seed potatoes. Several of the states have already had some experience along this line which would be valuable in extending the practice.

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LITERATURE ON PLANT DISEASES[1]

COMPILED BY EUNICE R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY, AND FLORENCE P. SMITH, ASSISTANT

February, 1918

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All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agri., Washington, D. C.

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